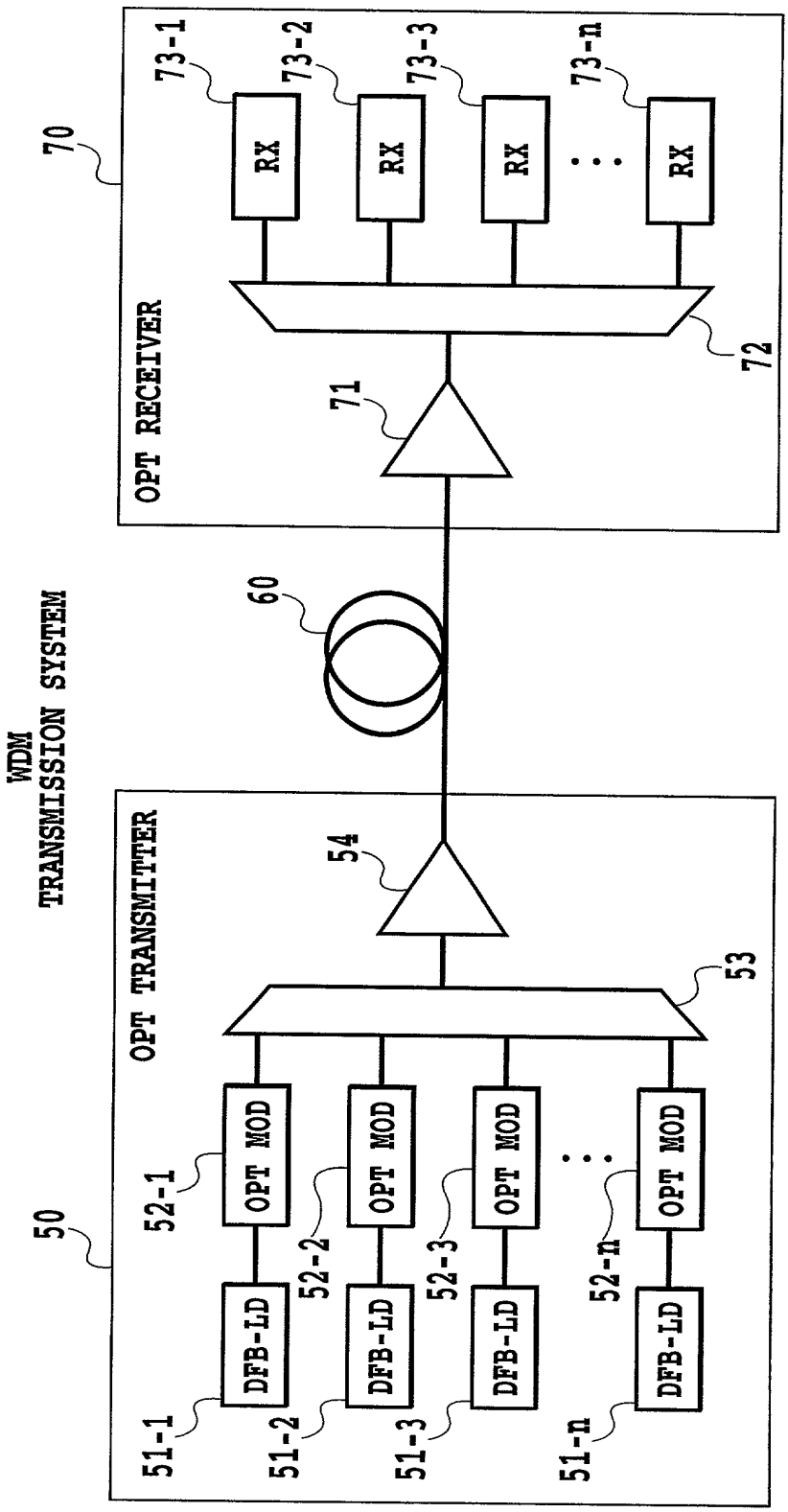


FIG.1
PRIOR ART

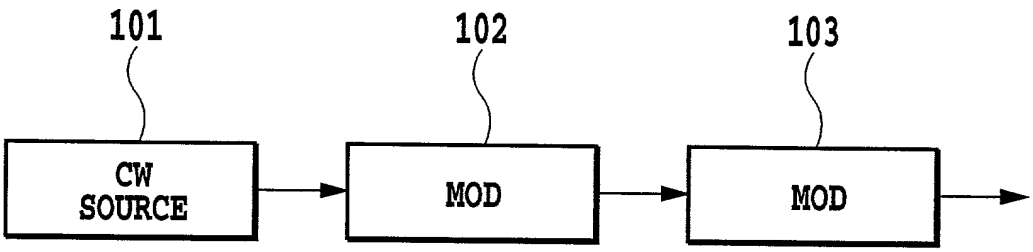


FIG.2

FIG.3A

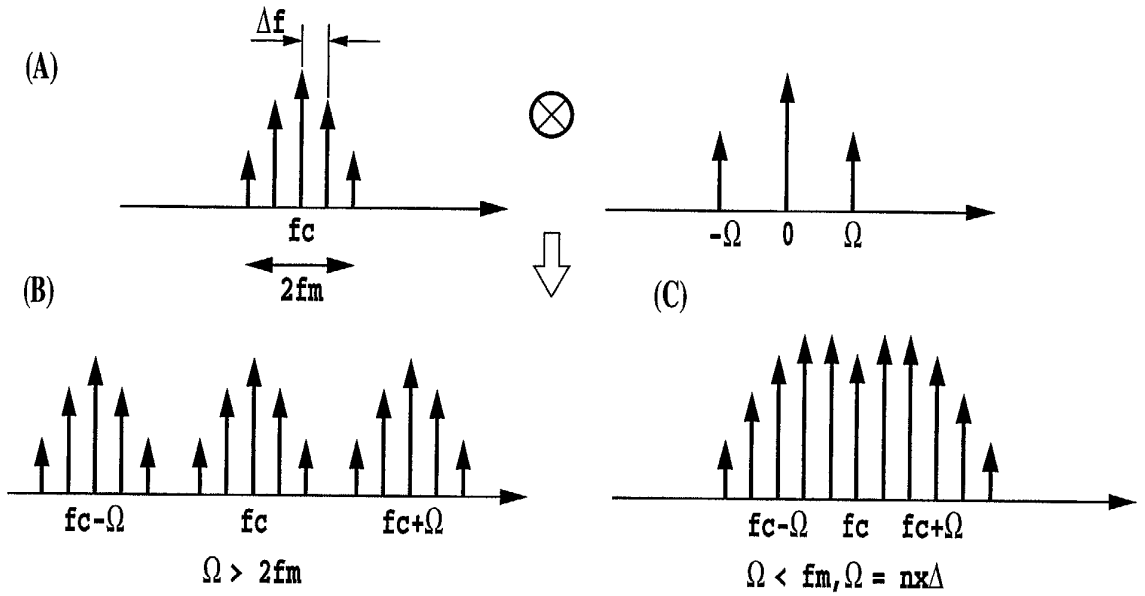
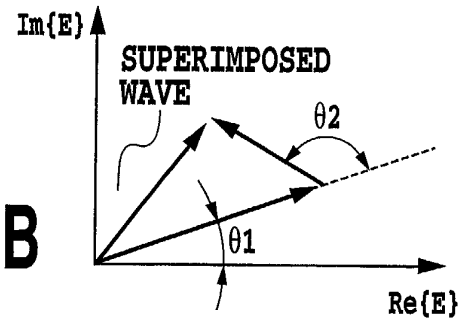
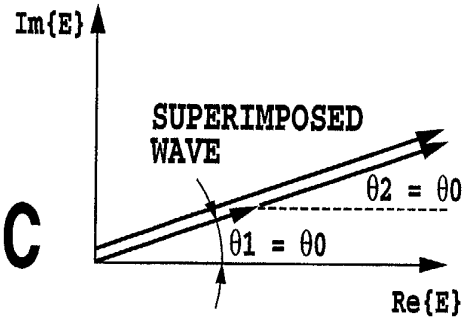


FIG.3B



ADDITION OF TWO MODES WITH DIFFERENT PHASES

FIG.3C



ADDITION OF TWO MODES WITH SAME PHASE

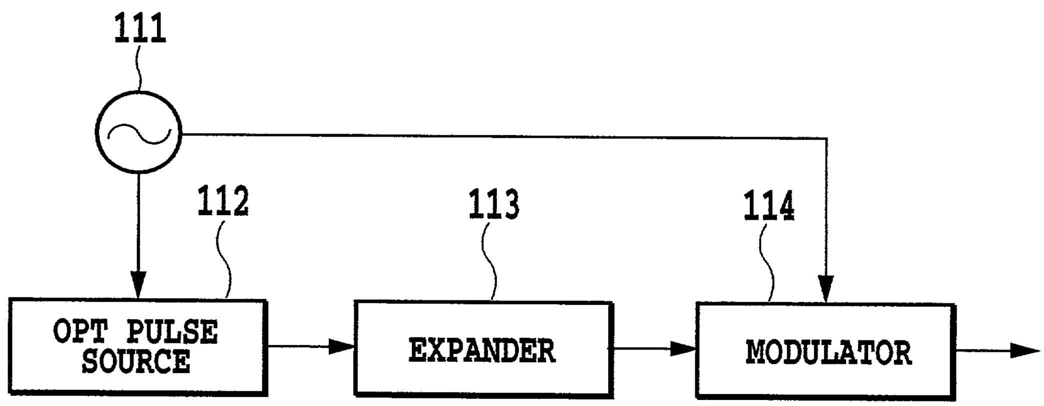


FIG.4

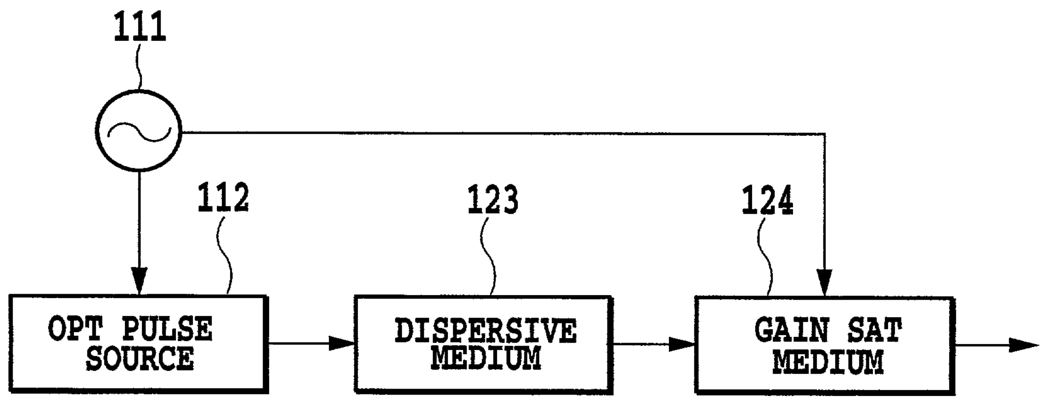

111
112
123
124
OPT PULSE SOURCE
DISPERSIVE MEDIUM
GAIN SAT MEDIUM

FIG.5

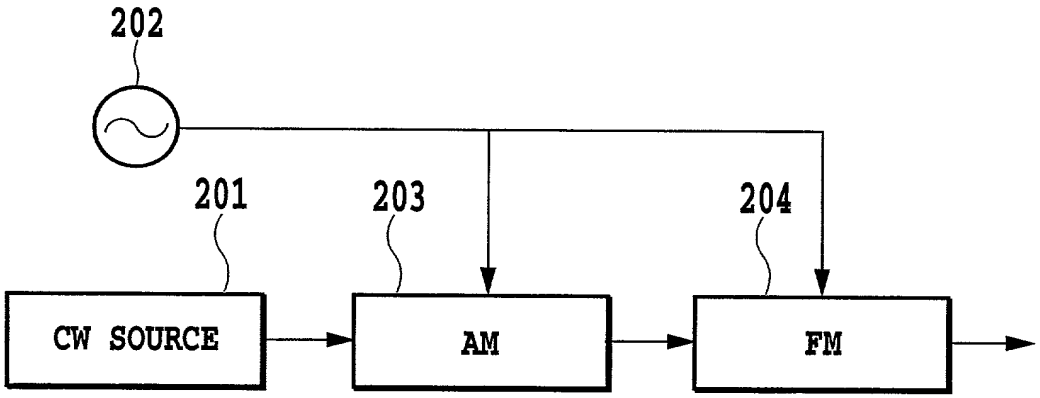


FIG.6

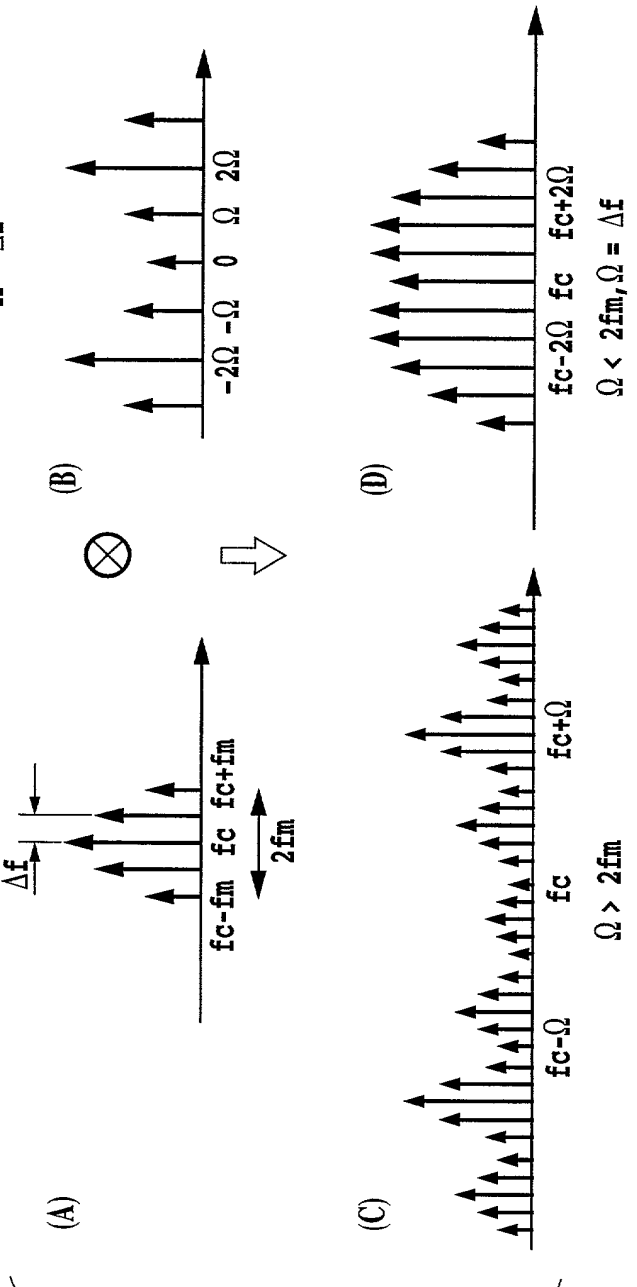


FIG.7

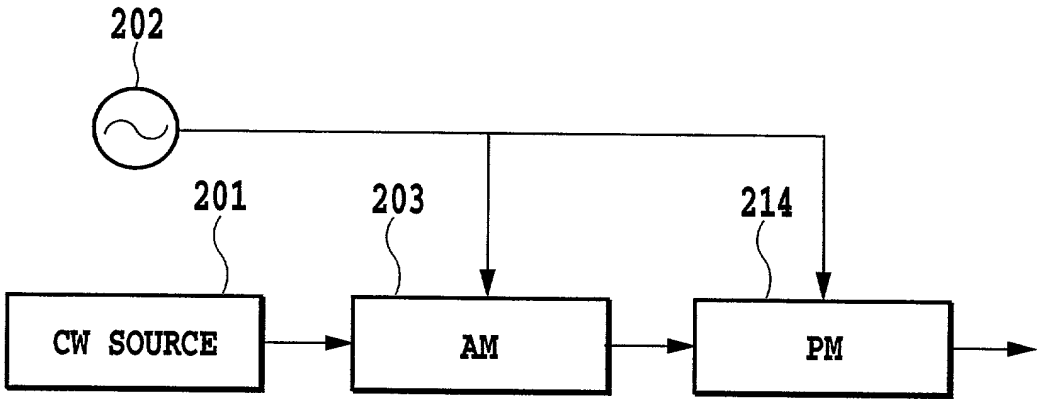


FIG.8

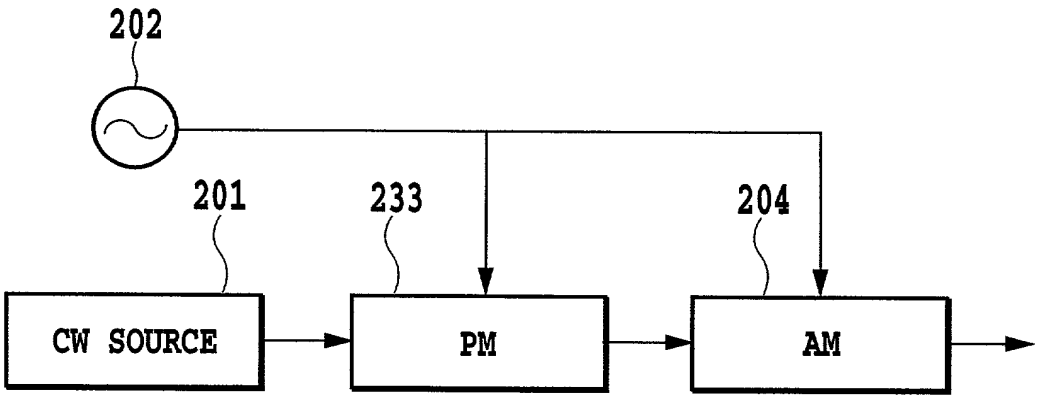


FIG.9

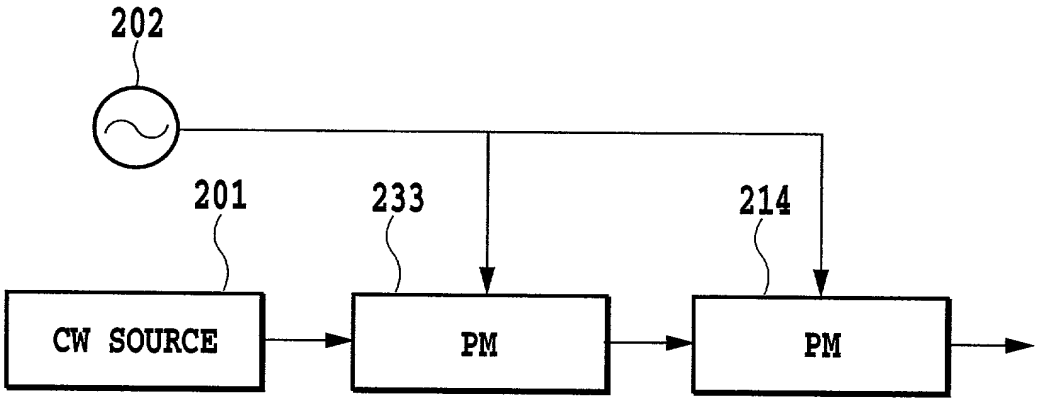


FIG.10

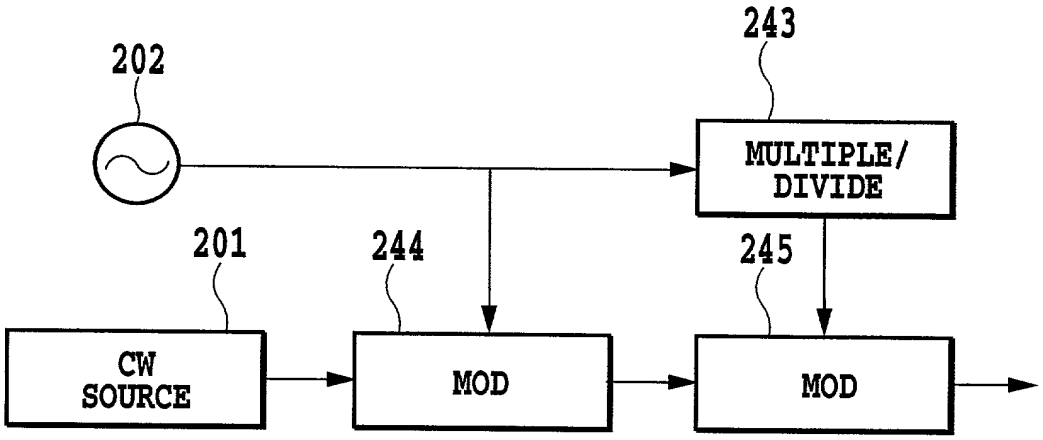


FIG.11

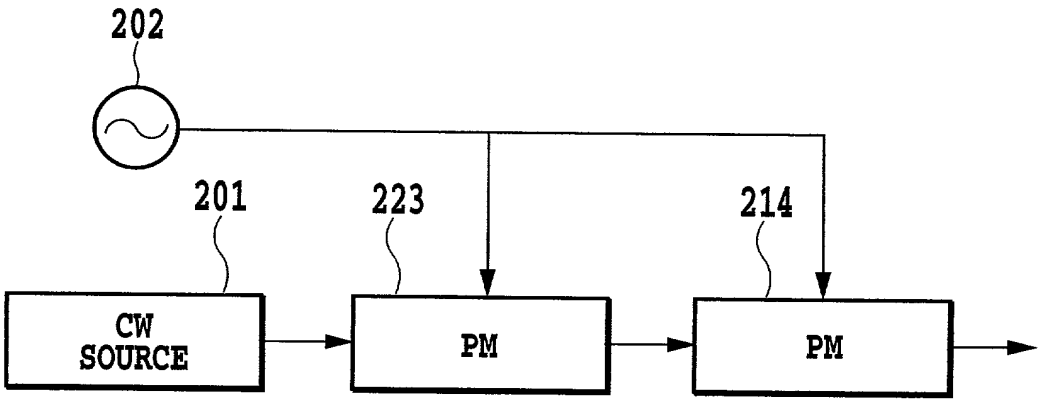


FIG.12

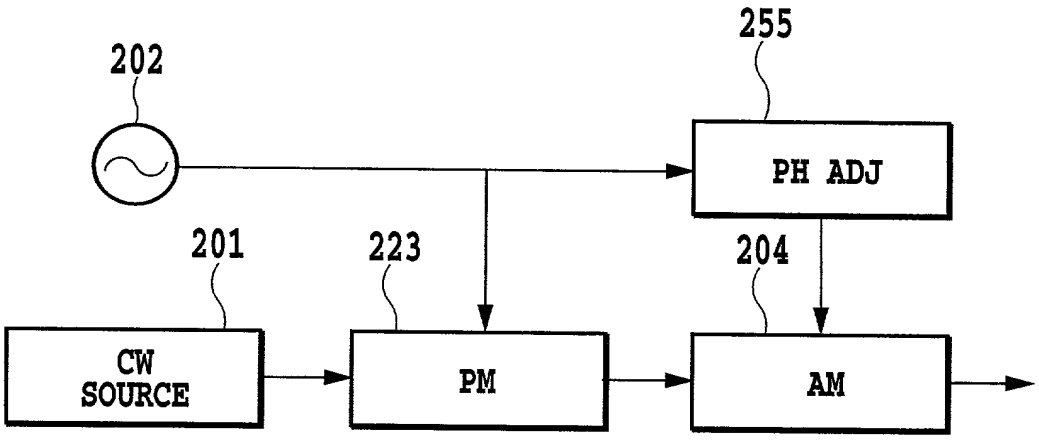


FIG.13

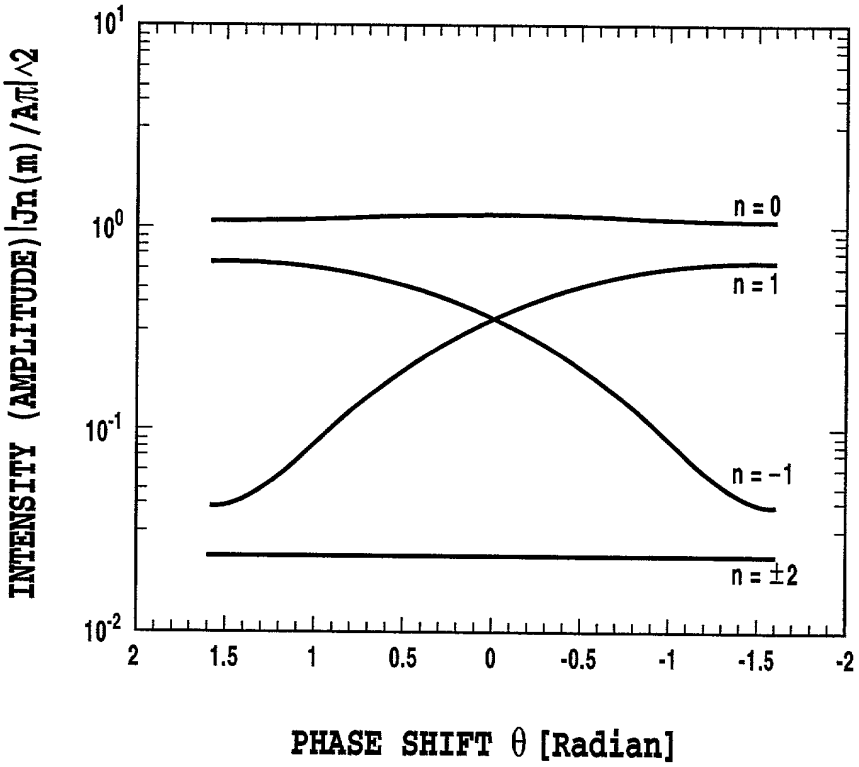
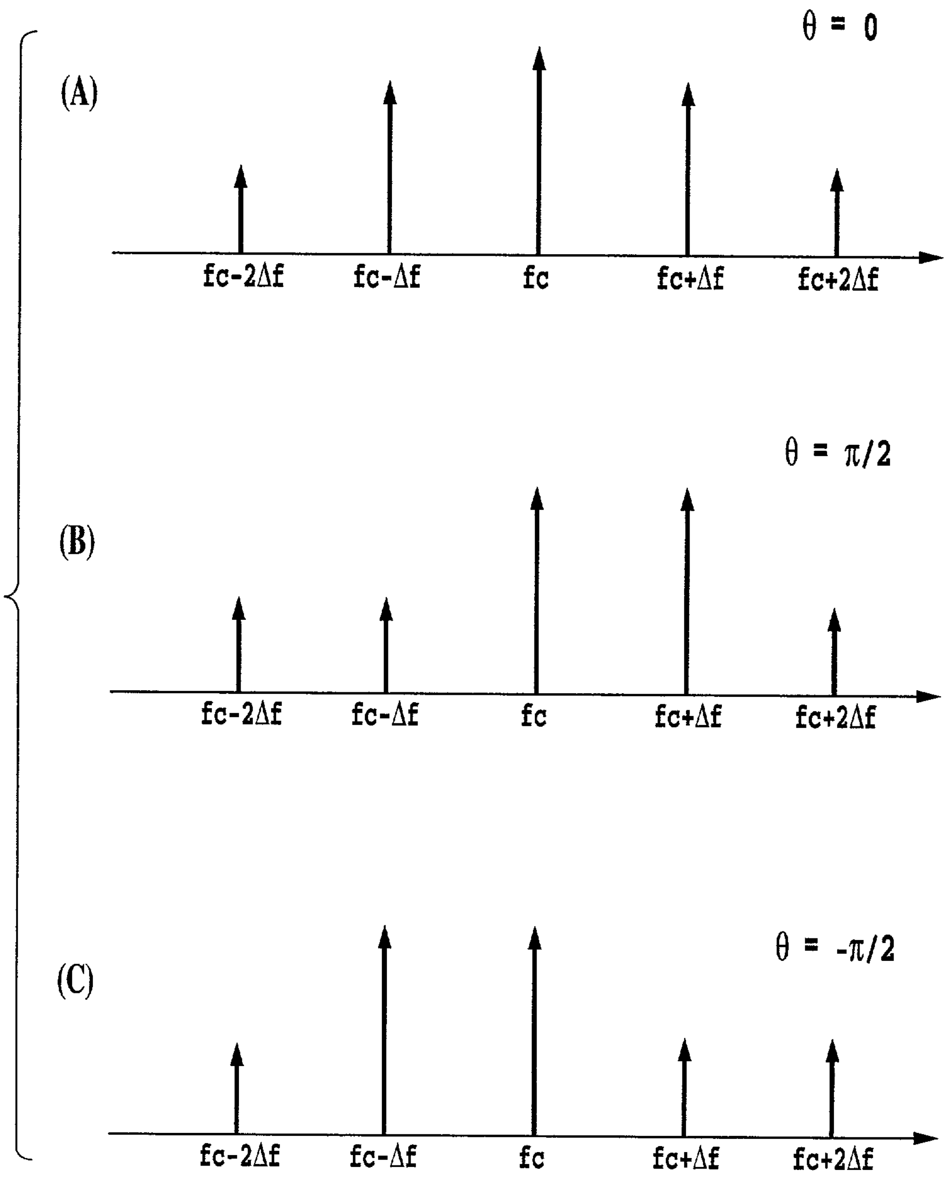

INTENSITY (AMPLITUDE) |Jn(m)/Aπ|^2
10^1
10^0
10^-1
10^-2
n = 0
n = 1
n = -1
n = ±2
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
PHASE SHIFT θ [Radian]

FIG.14

FIG.15


θ = 0
(A)
fc-2Δf
fc-Δf
fc
fc+Δf
fc+2Δf
θ = π/2
(B)
fc-2Δf
fc-Δf
fc
fc+Δf
fc+2Δf
θ = -π/2
(C)
fc-2Δf
fc-Δf
fc
fc+Δf
fc+2Δf

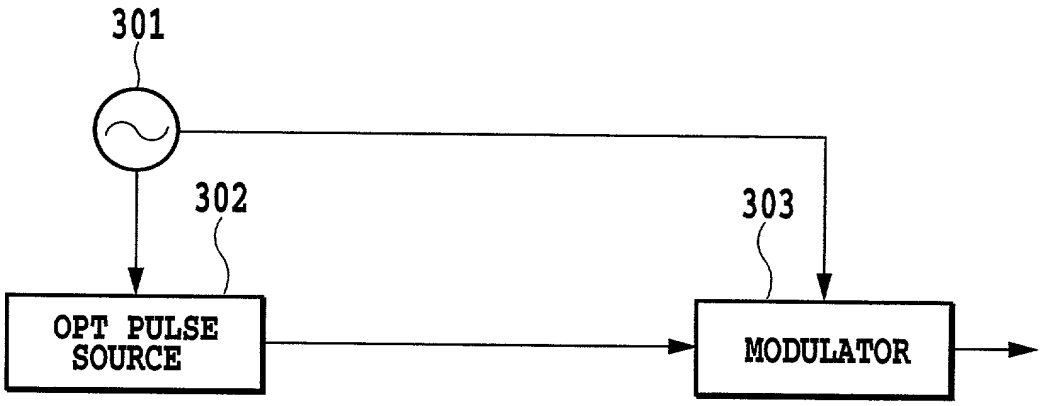


FIG.16

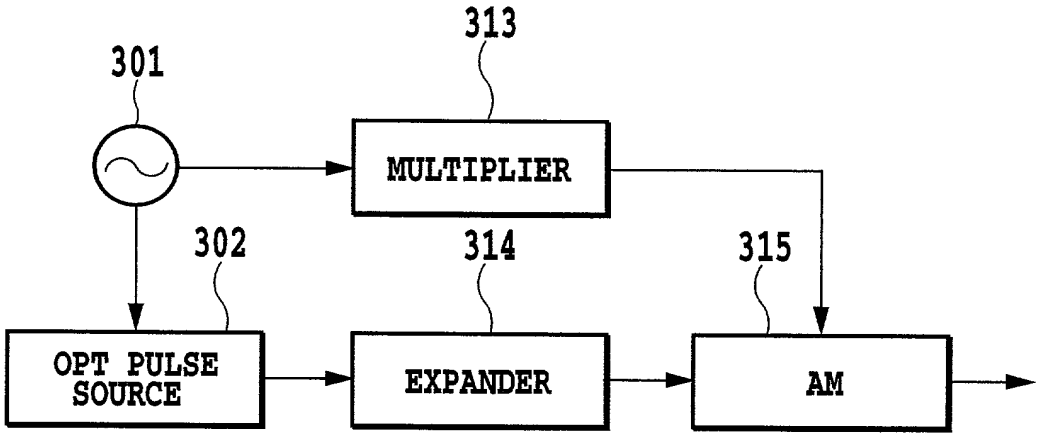


FIG.17

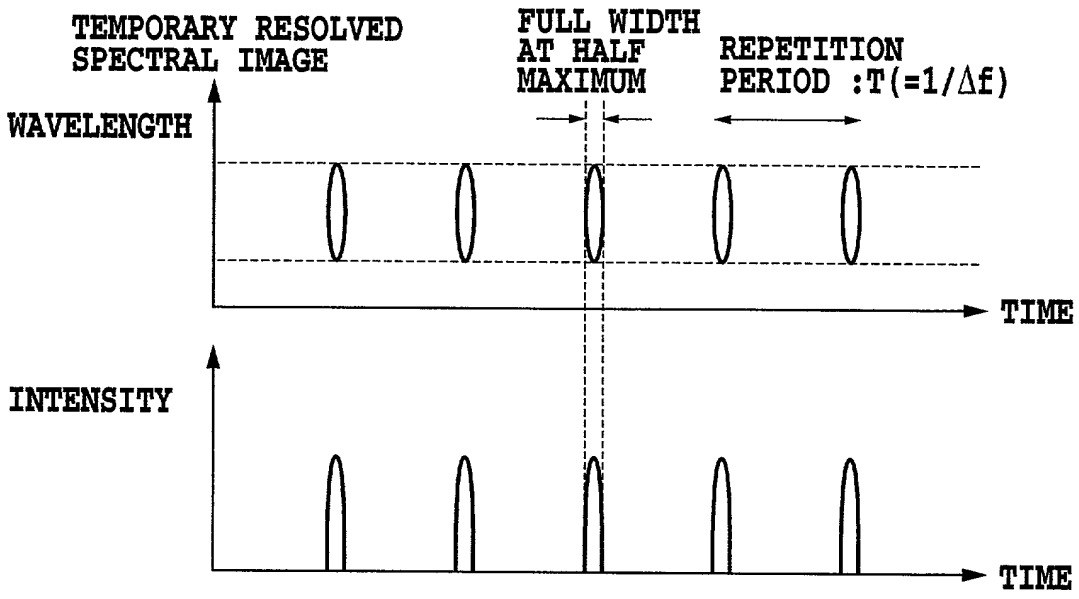

TEMPORARY RESOLVED
SPECTRAL IMAGE
FULL WIDTH
AT HALF
MAXIMUM
REPETITION
PERIOD :T(=1/Δf)
WAVELENGTH
TIME
INTENSITY
TIME

FIG.18

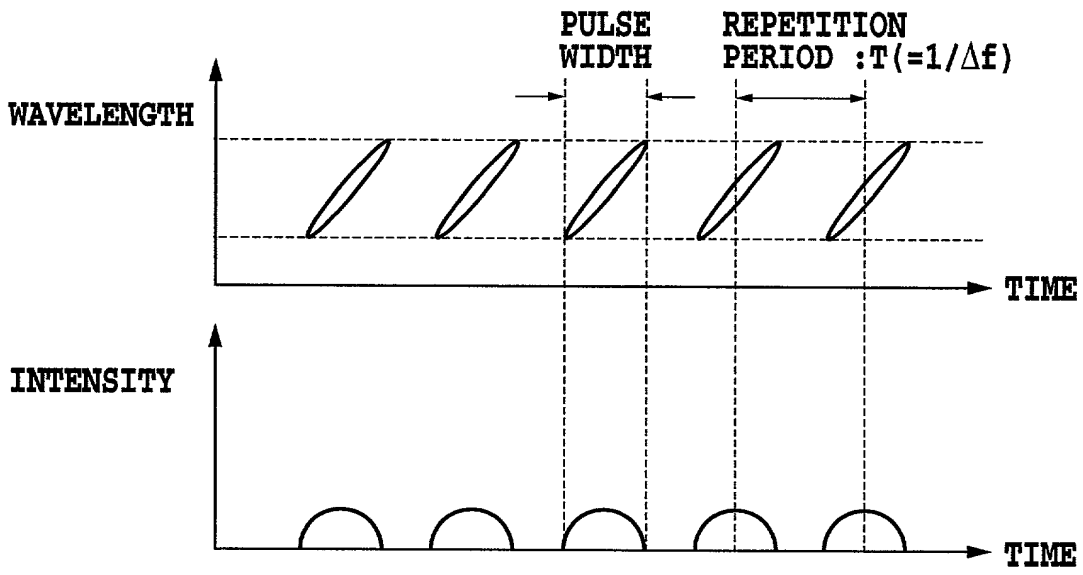

PULSE
WIDTH
REPETITION
PERIOD :T(=1/Δf)
WAVELENGTH
TIME
INTENSITY
TIME

FIG.19

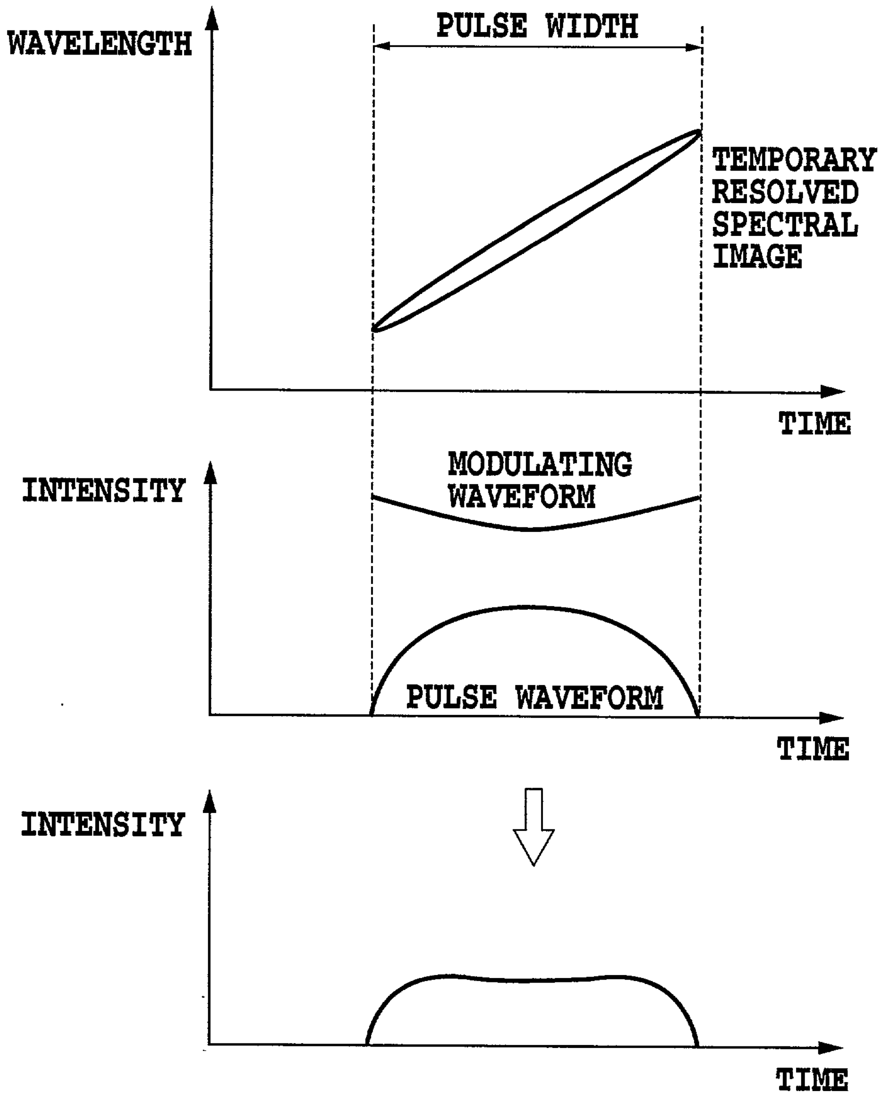

WAVELENGTH
PULSE WIDTH
TEMPORARY
RESOLVED
SPECTRAL
IMAGE
TIME
INTENSITY
MODULATING
WAVEFORM
PULSE WAVEFORM
TIME
INTENSITY
TIME

FIG.20

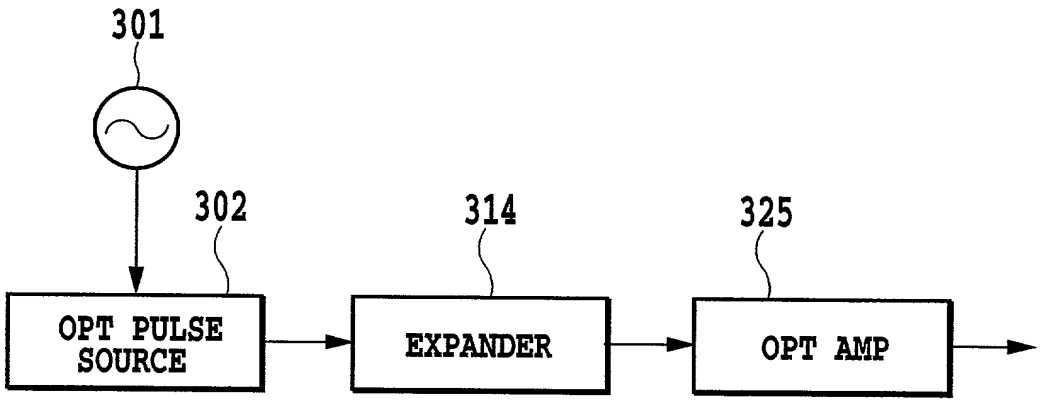


FIG.21

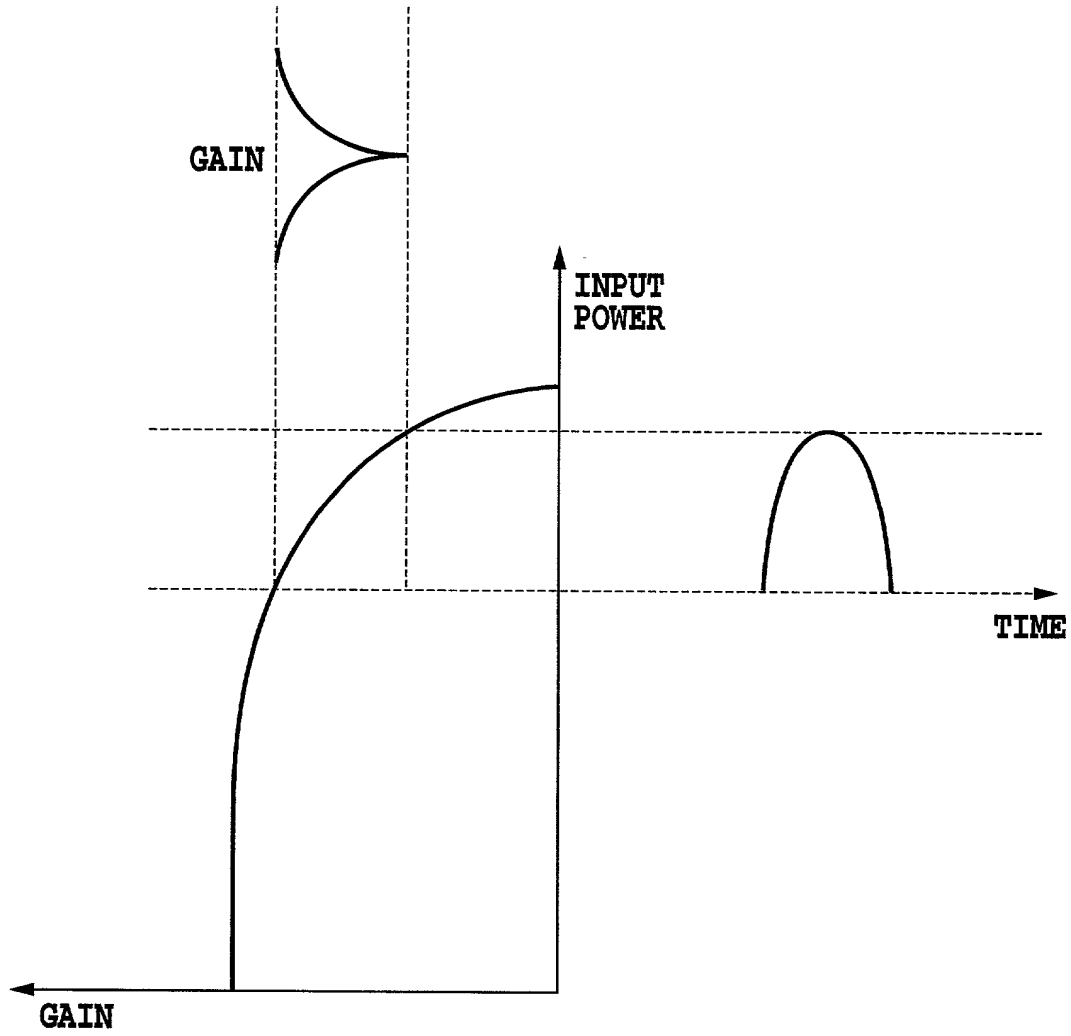


FIG.22

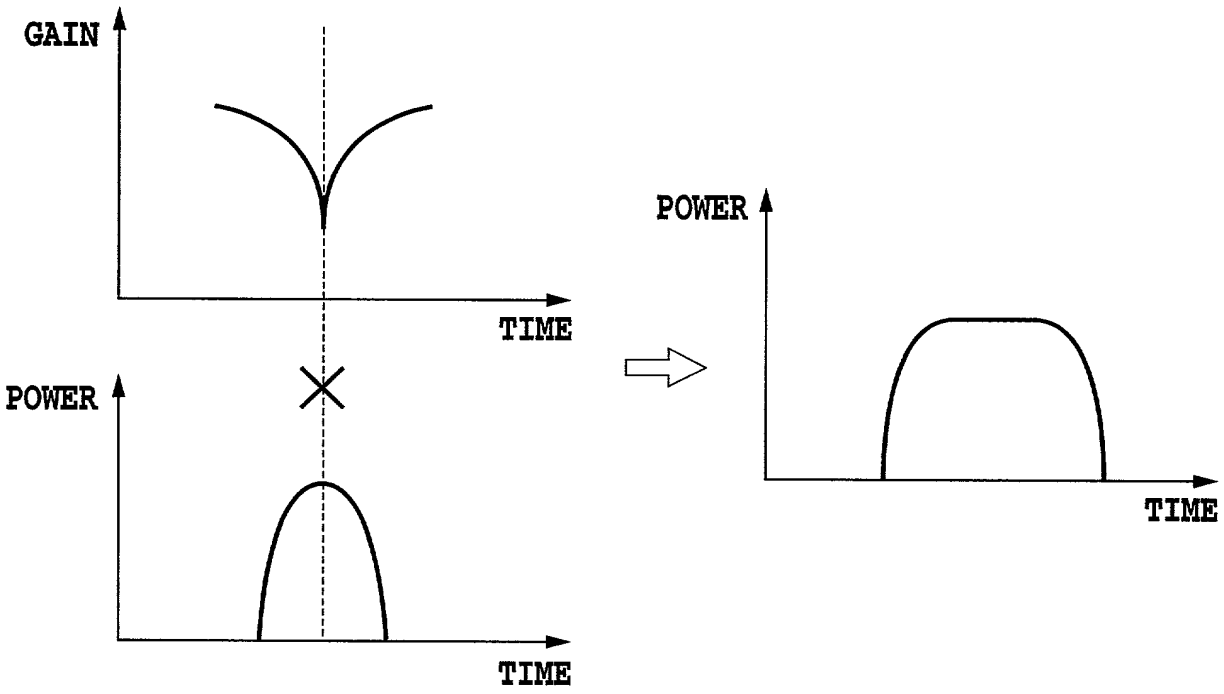


FIG.23

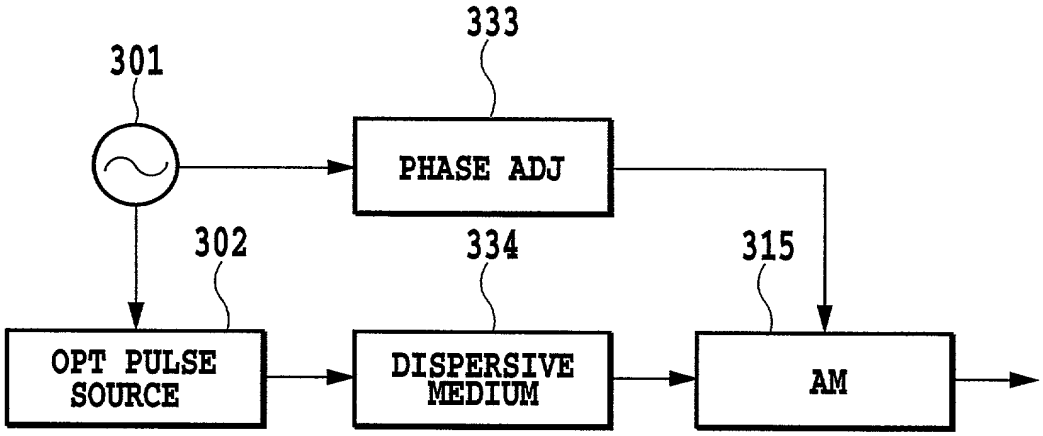

301
333
PHASE ADJ
302
334
315
OPT PULSE SOURCE
DISPERSIVE MEDIUM
AM

FIG.24

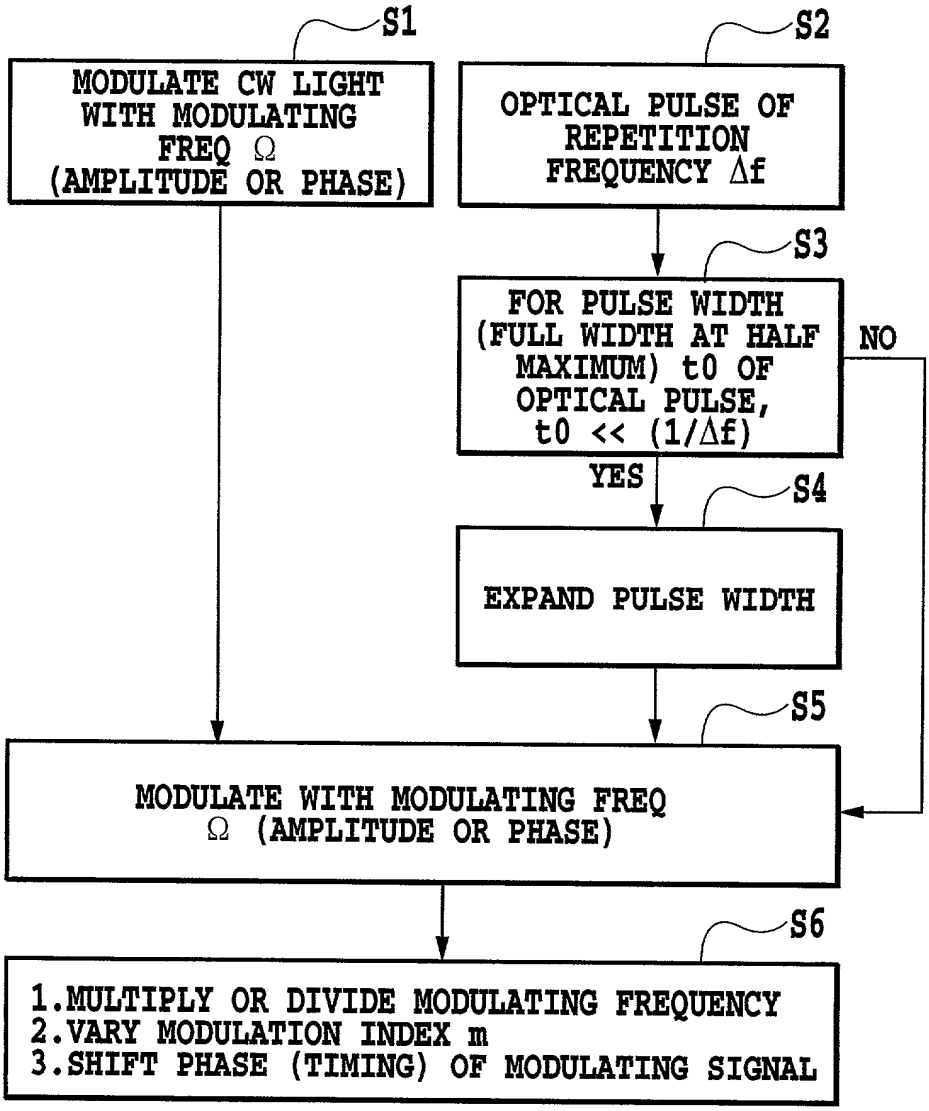

S1
MODULATE CW LIGHT WITH MODULATING FREQ Ω (AMPLITUDE OR PHASE)
S2
OPTICAL PULSE OF REPETITION FREQUENCY Δf
S3
FOR PULSE WIDTH (FULL WIDTH AT HALF MAXIMUM) t0 OF OPTICAL PULSE, t0 << (1/Δf)
NO
YES
S4
EXPAND PULSE WIDTH
S5
MODULATE WITH MODULATING FREQ Ω (AMPLITUDE OR PHASE)
S6
1.MULTIPLY OR DIVIDE MODULATING FREQUENCY
2.VARY MODULATION INDEX m
3.SHIFT PHASE (TIMING) OF MODULATING SIGNAL

FIG.25

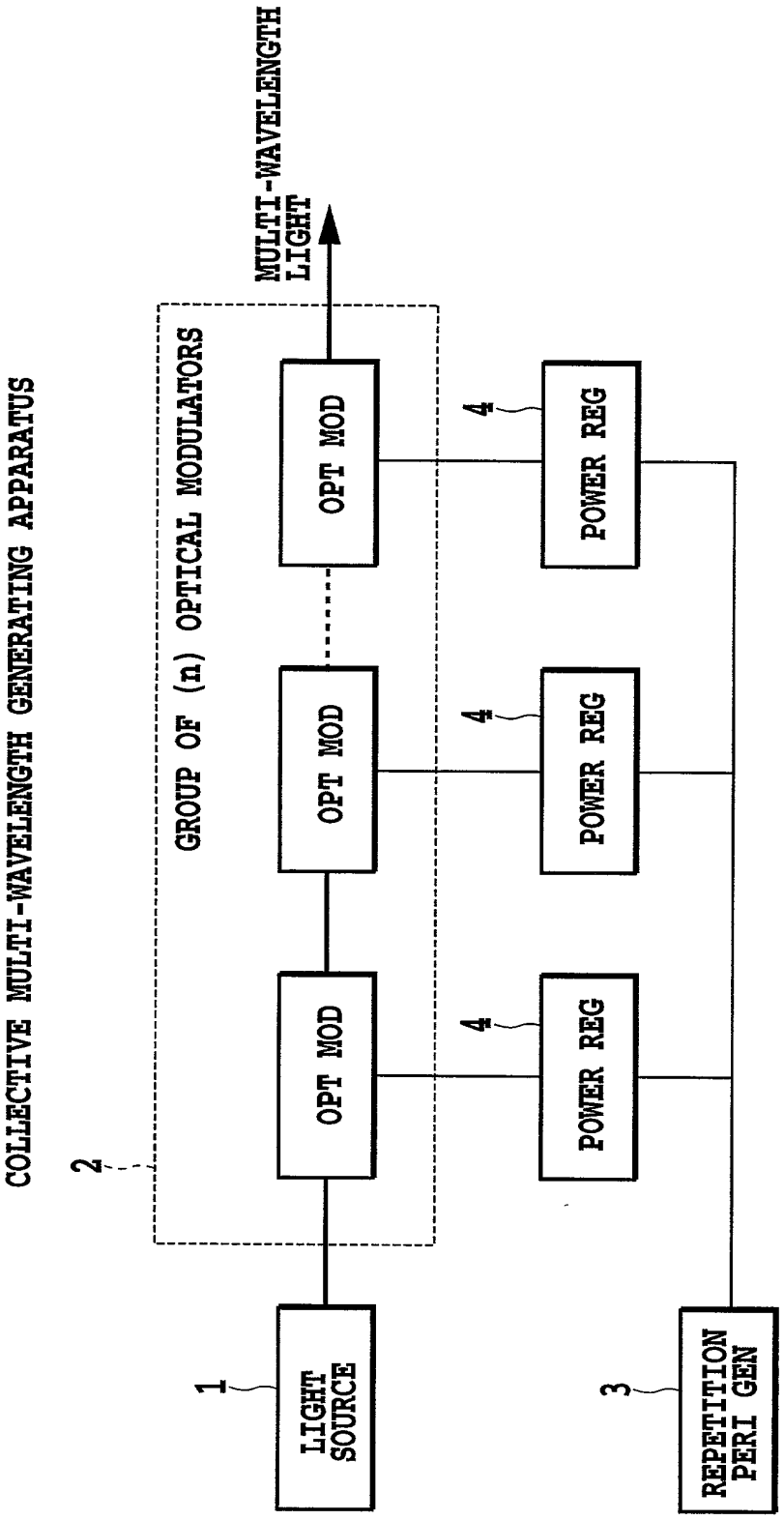

COLLECTIVE MULTI-WAVELENGTH GENERATING APPARATUS
2
GROUP OF (n) OPTICAL MODULATORS
MULTI-WAVELENGTH LIGHT
OPT MOD
OPT MOD
OPT MOD
4
4
4
POWER REG
POWER REG
POWER REG
1
LIGHT SOURCE
3
REPETITION PERI GEN

FIG.26

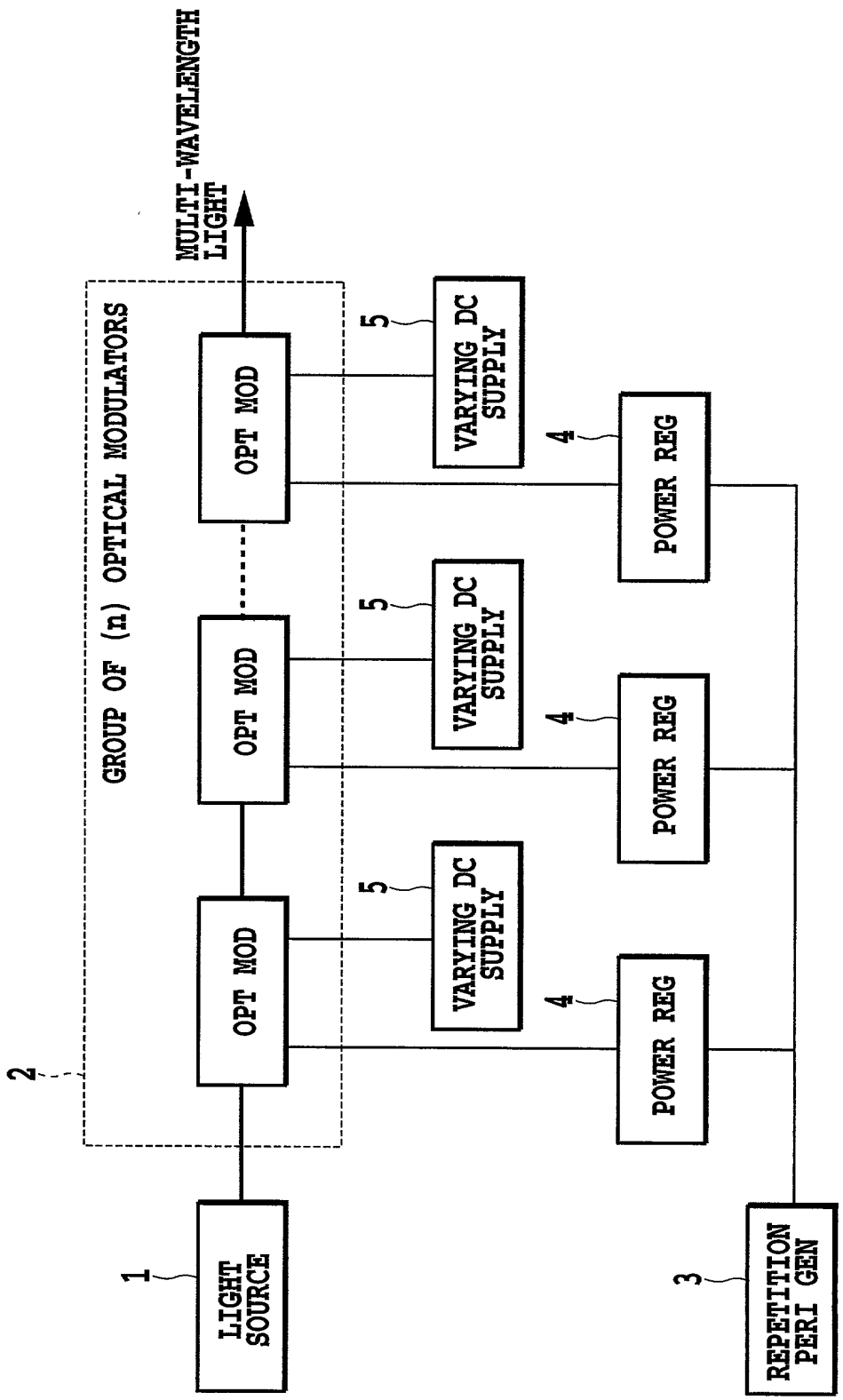

MULTI-WAVELENGTH LIGHT
GROUP OF (n) OPTICAL MODULATORS
OPT MOD
OPT MOD
OPT MOD
VARYING DC SUPPLY
VARYING DC SUPPLY
VARYING DC SUPPLY
POWER REG
POWER REG
POWER REG
LIGHT SOURCE
REPETTION PERI GEN
1
2
3
4
5

FIG.27

FIG.28

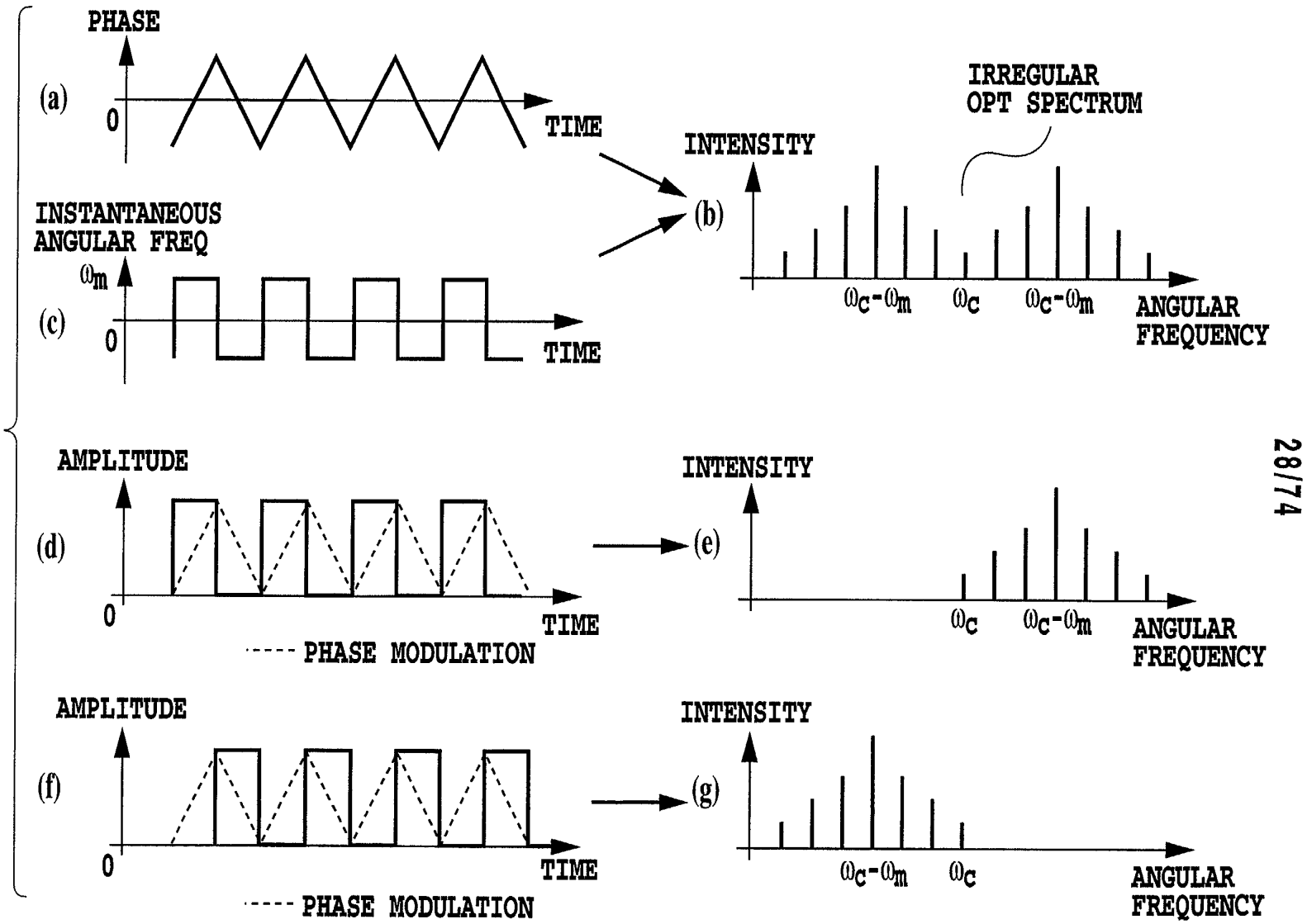
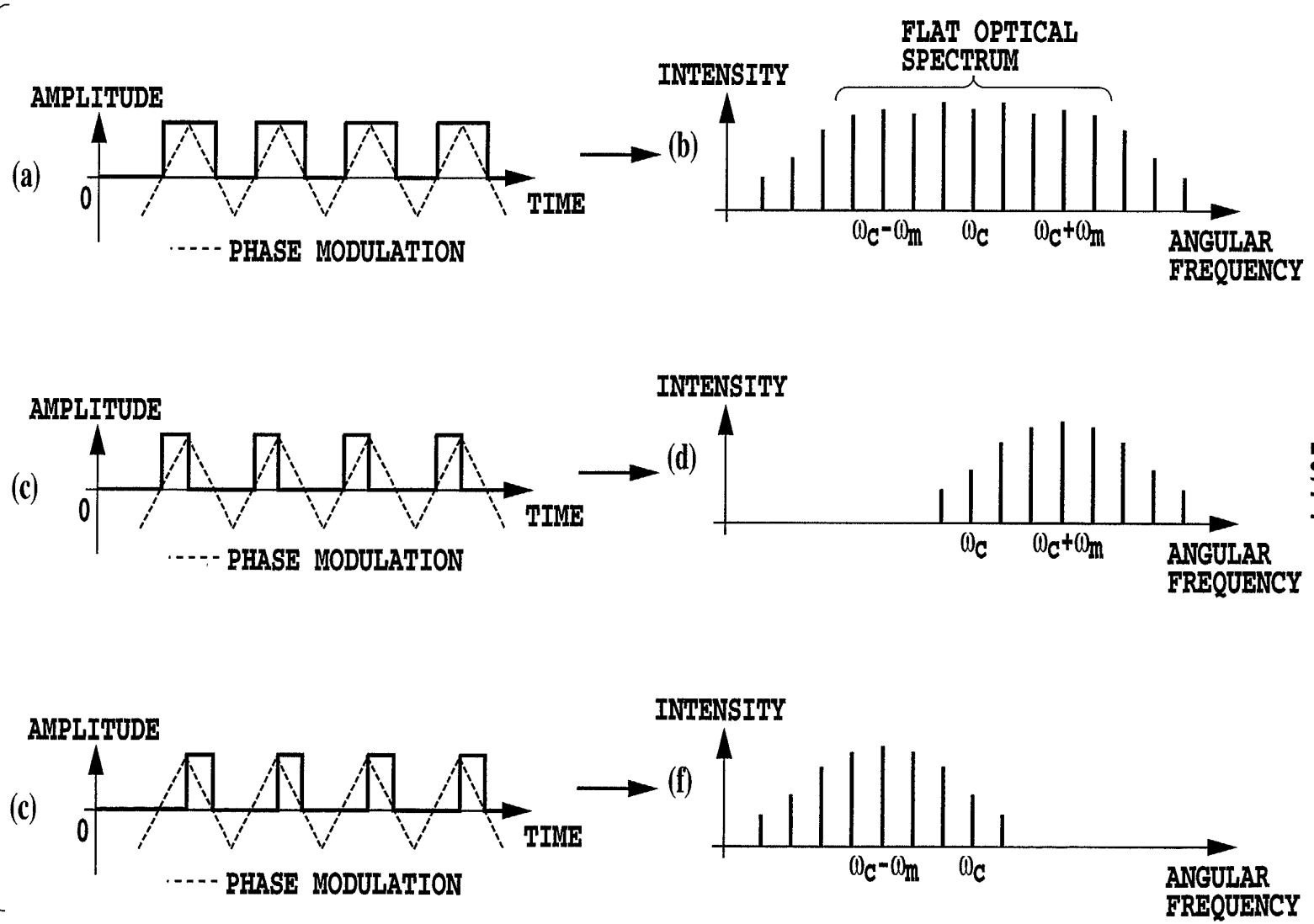

FLATTENING OPTICAL SPECTRUM BY MULTI-WAVELENGTH GENERATING APPARATUS
PHASE
(a)
0
TIME
IRREGULAR
OPT SPECTRUM
INTENSITY
INSTANTANEOUS
ANGULAR FREQ
(b)
(c)
ωm
0
TIME
ωc-ωm
ωc
ωc-ωm
ANGULAR
FREQUENCY
AMPLITUDE
INTENSITY
(d)
(e)
0
TIME
PHASE MODULATION
ωc
ωc-ωm
ANGULAR
FREQUENCY
AMPLITUDE
INTENSITY
(f)
(g)
0
TIME
PHASE MODULATION
ωc-ωm
ωc
ANGULAR
FREQUENCY

FIG.29


AMPLITUDE
(a)
0
TIME
PHASE MODULATION
INTENSITY
FLAT OPTICAL SPECTRUM
(b)
$\omega_c-\omega_m$
ω_c
$\omega_c+\omega_m$
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
INTENSITY
(d)
ω_c
$\omega_c+\omega_m$
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
INTENSITY
(f)
$\omega_c-\omega_m$
ω_c
ANGULAR FREQUENCY

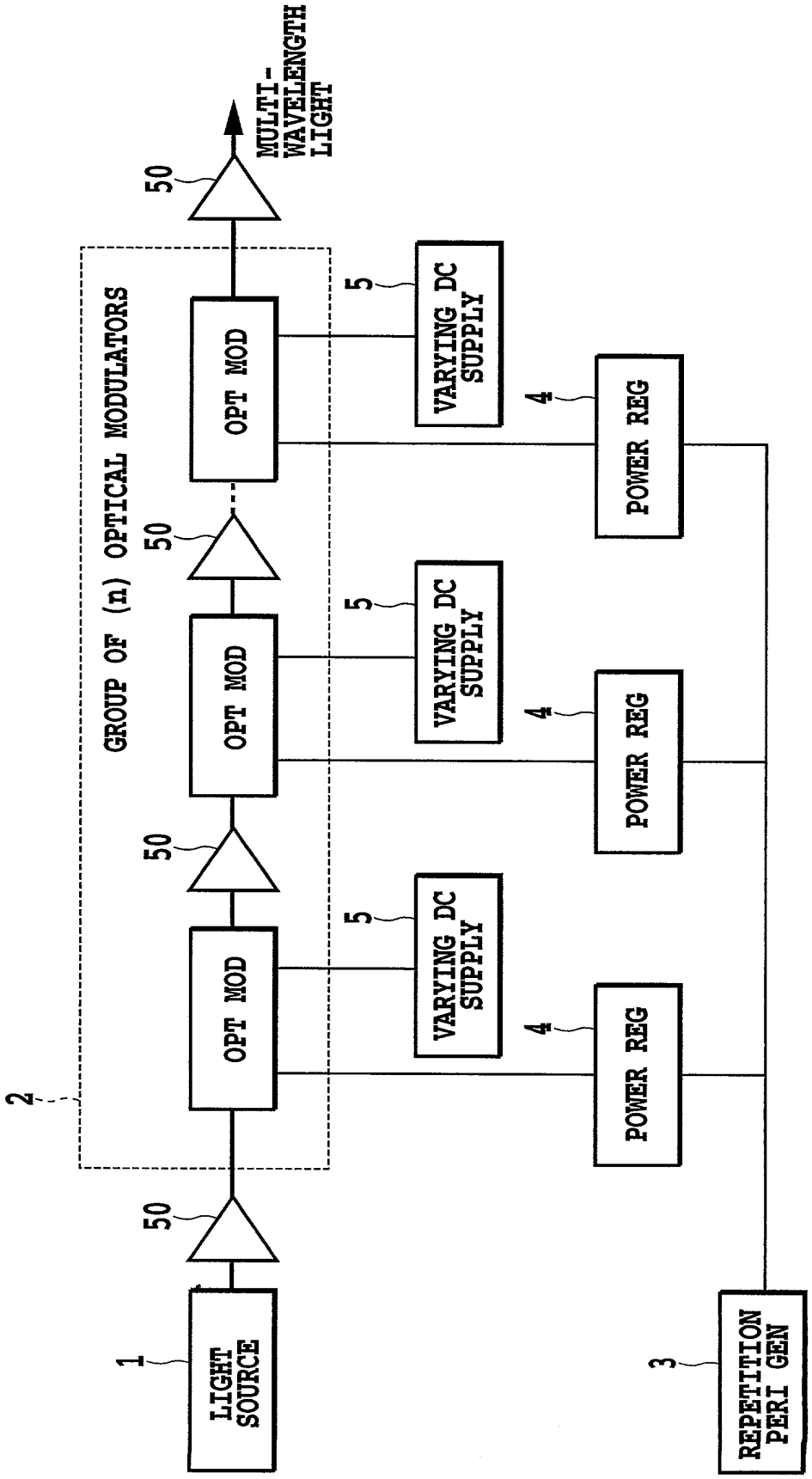

MULTI-WAVELENGTH LIGHT
GROUP OF (n) OPTICAL MODULATORS
LIGHT SOURCE
OPT MOD
OPT MOD
OPT MOD
VARYING DC SUPPLY
VARYING DC SUPPLY
VARYING DC SUPPLY
POWER REG
POWER REG
POWER REG
REPETITION PERI GEN
1
2
3
4
5
50
50
50
50

FIG.30

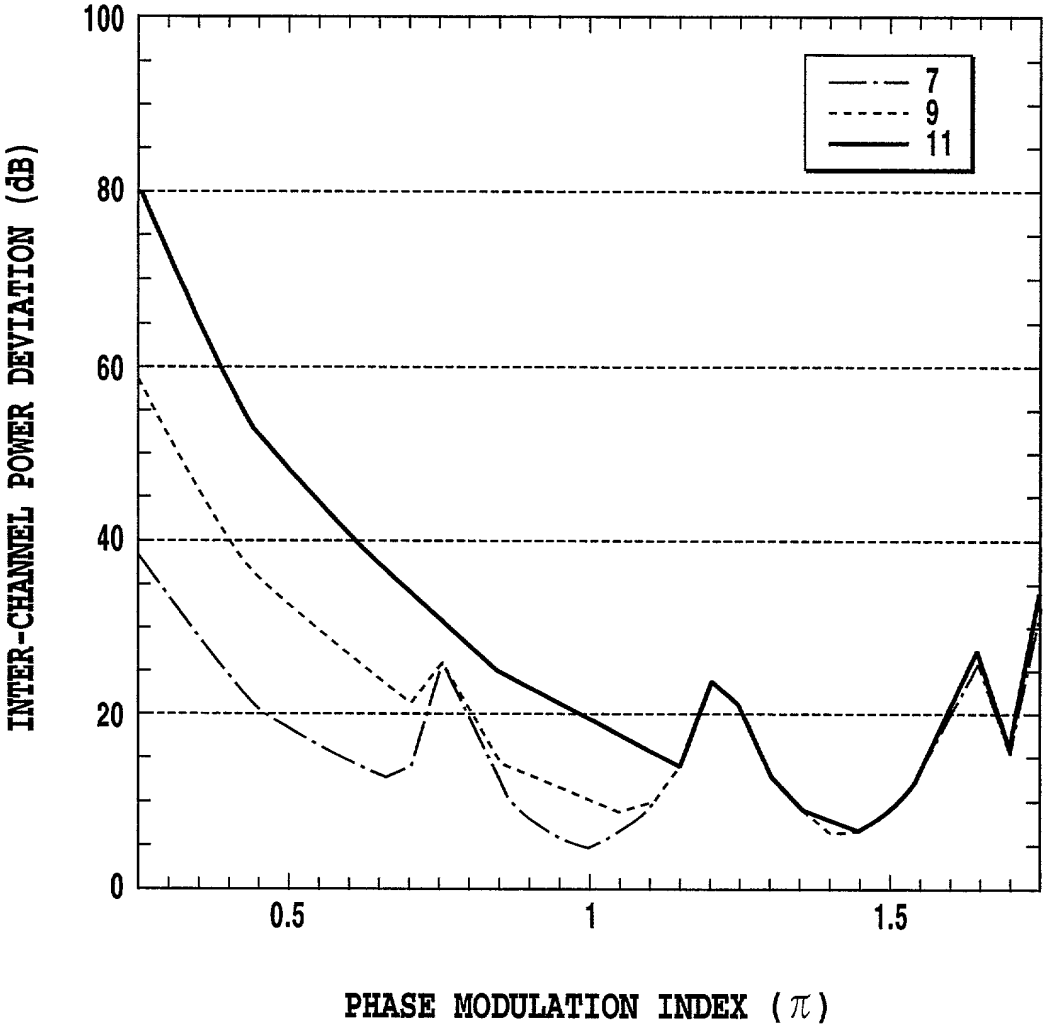
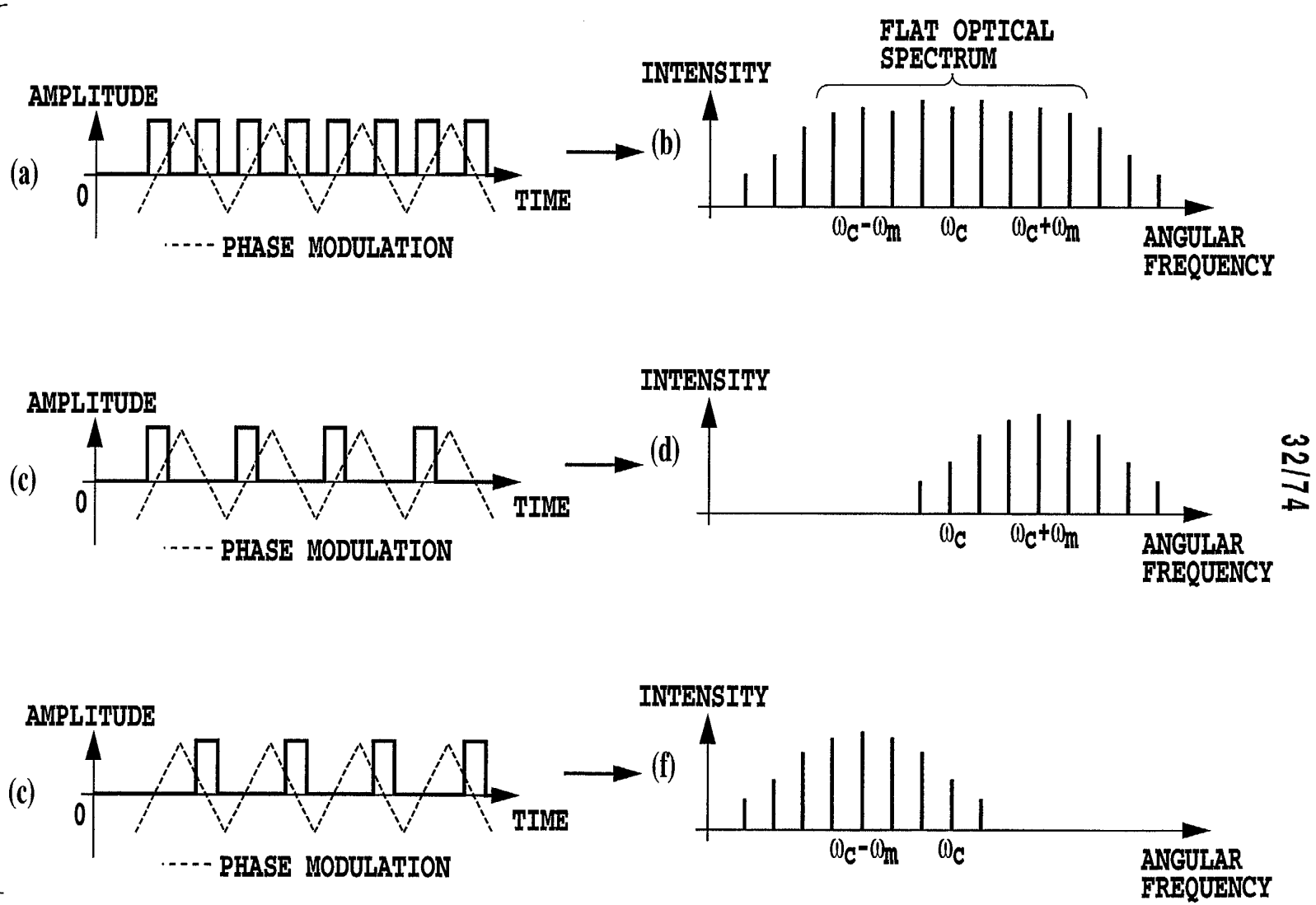

100
80
60
40
20
0
0.5
1
1.5
7
9
11
INTER-CHANNEL POWER DEVIATION (dB)
PHASE MODULATION INDEX (π)

FIG.31

FIG.32


AMPLITUDE
(a)
0
TIME
PHASE MODULATION
FLAT OPTICAL SPECTRUM
INTENSITY
(b)
$\omega_c-\omega_m$
ω_c
$\omega_c+\omega_m$
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
INTENSITY
(d)
ω_c
$\omega_c+\omega_m$
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
INTENSITY
(f)
$\omega_c-\omega_m$
ω_c
ANGULAR FREQUENCY

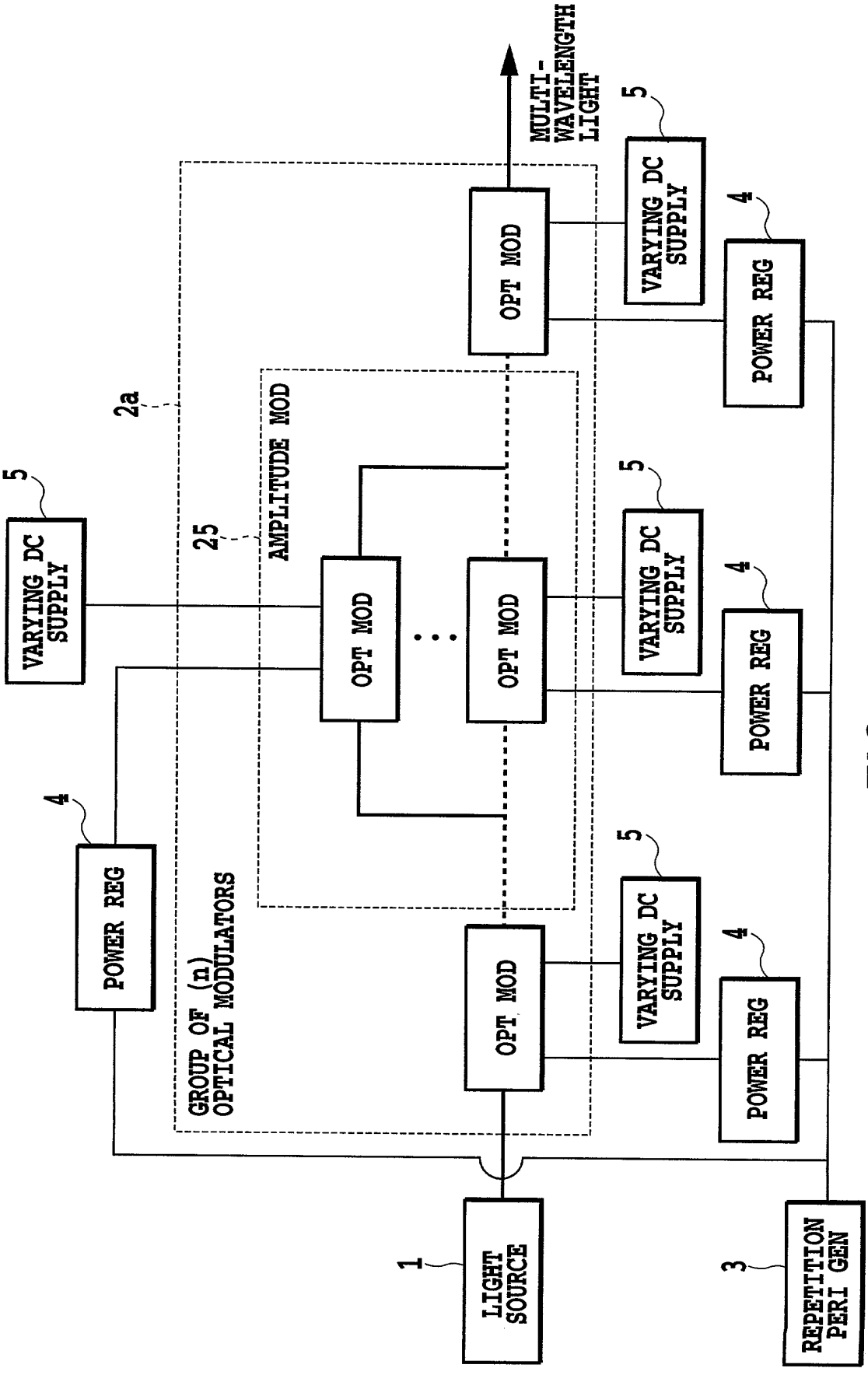

MULTI-WAVELENGTH LIGHT
2a
25
AMPLITUDE MOD
GROUP OF (n) OPTICAL MODULATORS
OPT MOD
OPT MOD
OPT MOD
VARYING DC SUPPLY
VARYING DC SUPPLY
VARYING DC SUPPLY
POWER REG
POWER REG
POWER REG
5
5
5
4
4
4
LIGHT SOURCE
1
REPETITION PERI GEN
3

FIG.33

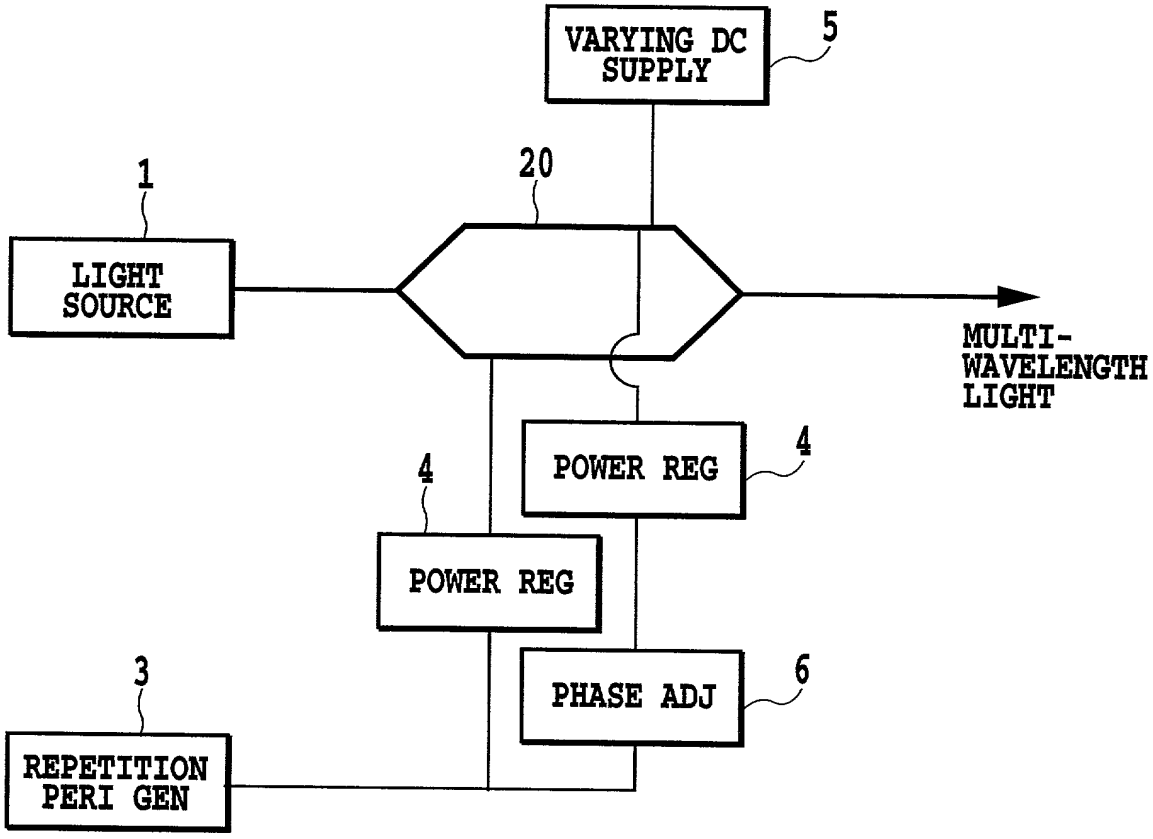

VARYING DC SUPPLY
5
1
20
LIGHT SOURCE
MULTI-WAVELENGTH LIGHT
POWER REG
4
4
POWER REG
3
PHASE ADJ
6
REPETITION PERI GEN

FIG.34

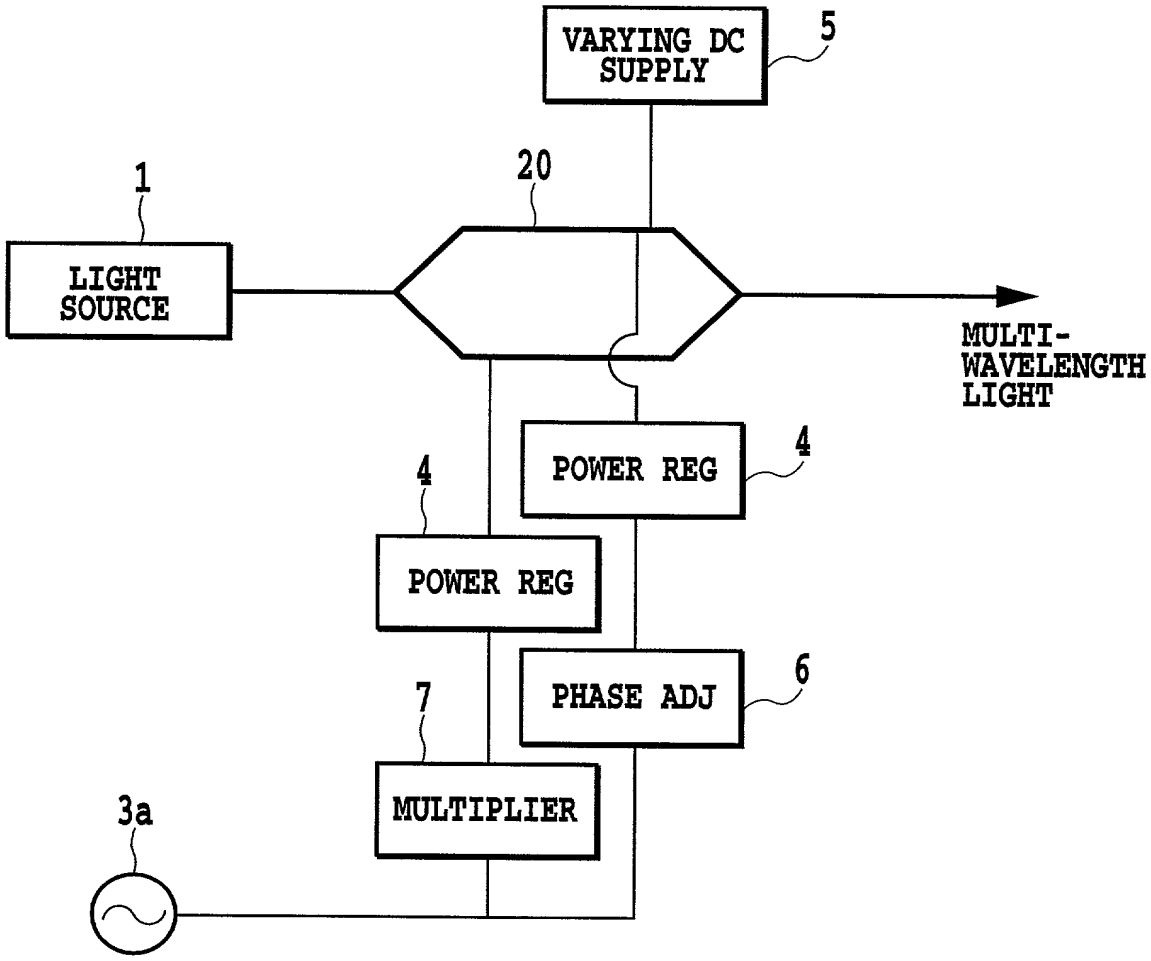

VARYING DC SUPPLY
5
1
20
LIGHT SOURCE
MULTI-WAVELENGTH LIGHT
4
POWER REG
4
4
POWER REG
7
PHASE ADJ
6
MULTIPLIER
3a

FIG.35

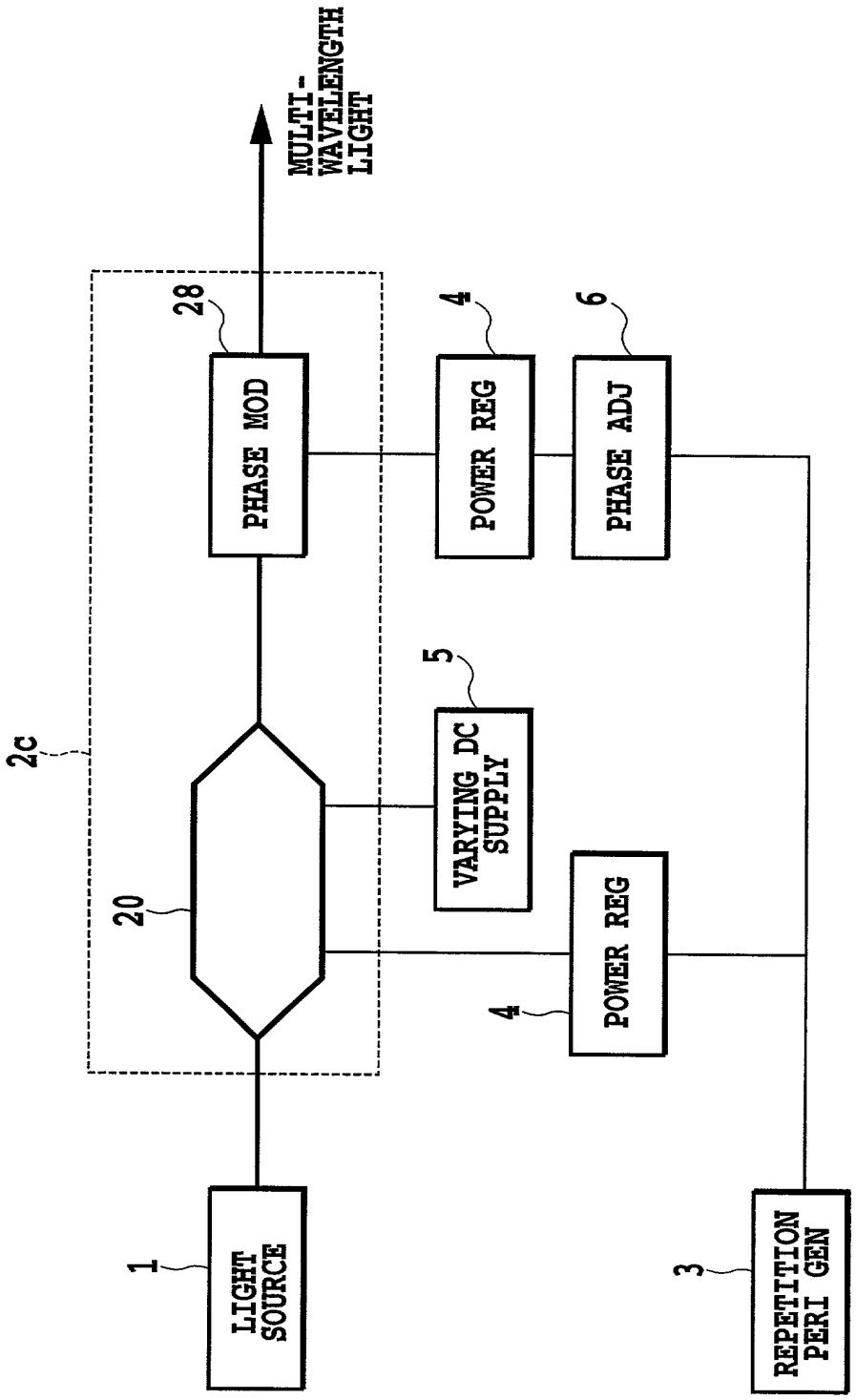

MULTI-
WAVELENGTH
LIGHT
28
PHASE MOD
4
POWER REG
6
PHASE ADJ
2c
5
VARYING DC
SUPPLY
20
4
POWER REG
1
LIGHT
SOURCE
3
REPETITION
PERI GEN

FIG.36

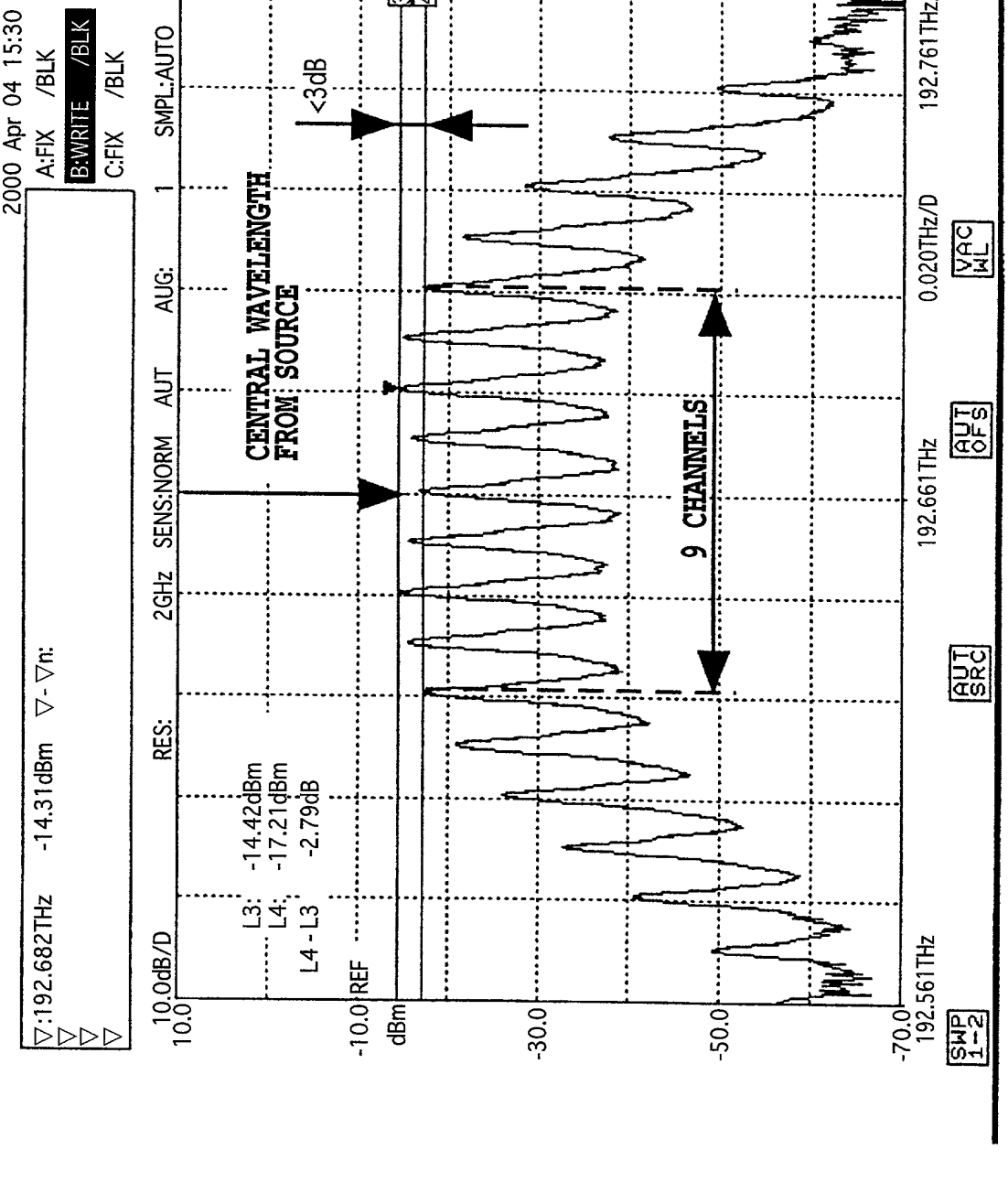

EXPERIMENTAL RESULT USING MACH-ZEHNDER
2000 Apr 04 15:30
A:FIX /BLK
B:WRITE /BLK
C:FIX /BLK
▽:192.682THz -14.31dBm ▽-▽n:
10.0dB/D
RES: 2GHz SENS:NORM AUT AUG: 1 SMPL:AUTO
L3: -14.42dBm
L4: -17.21dBm
L4 - L3 -2.79dB
REF
dBm
10.0
-10.0
-30.0
-50.0
-70.0
CENTRAL WAVELENGTH FROM SOURCE
<3dB
9 CHANNELS
192.561THz
192.661THz
0.020THz/D
192.761THz/D
SWP 1-2
AUT SRC
AUT OFS
VAC WL

FIG.37

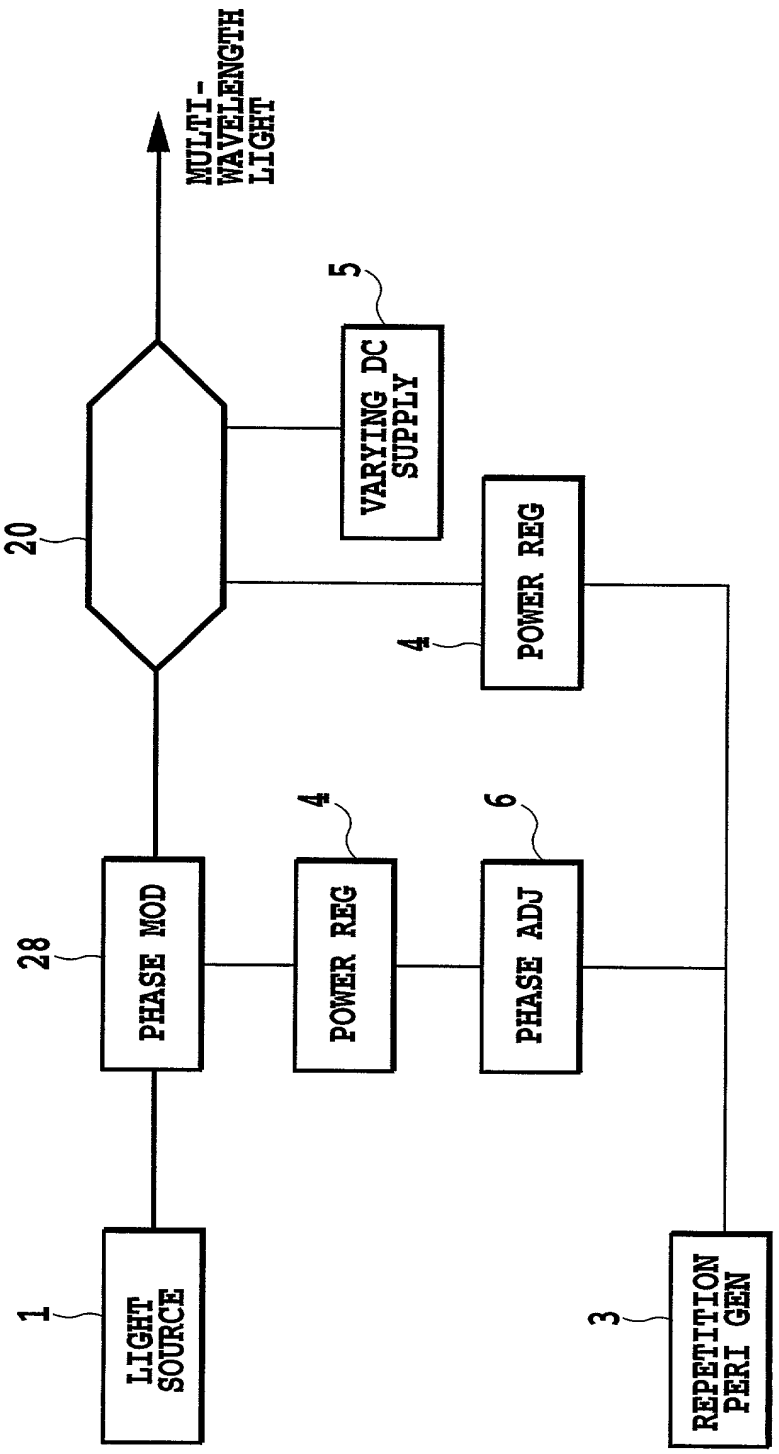

MULTI-
WAVELENGTH
LIGHT
5
VARYING DC
SUPPLY
20
4
POWER REG
28
PHASE MOD
4
POWER REG
6
PHASE ADJ
1
LIGHT
SOURCE
3
REPETITION
PERI GEN

FIG.38

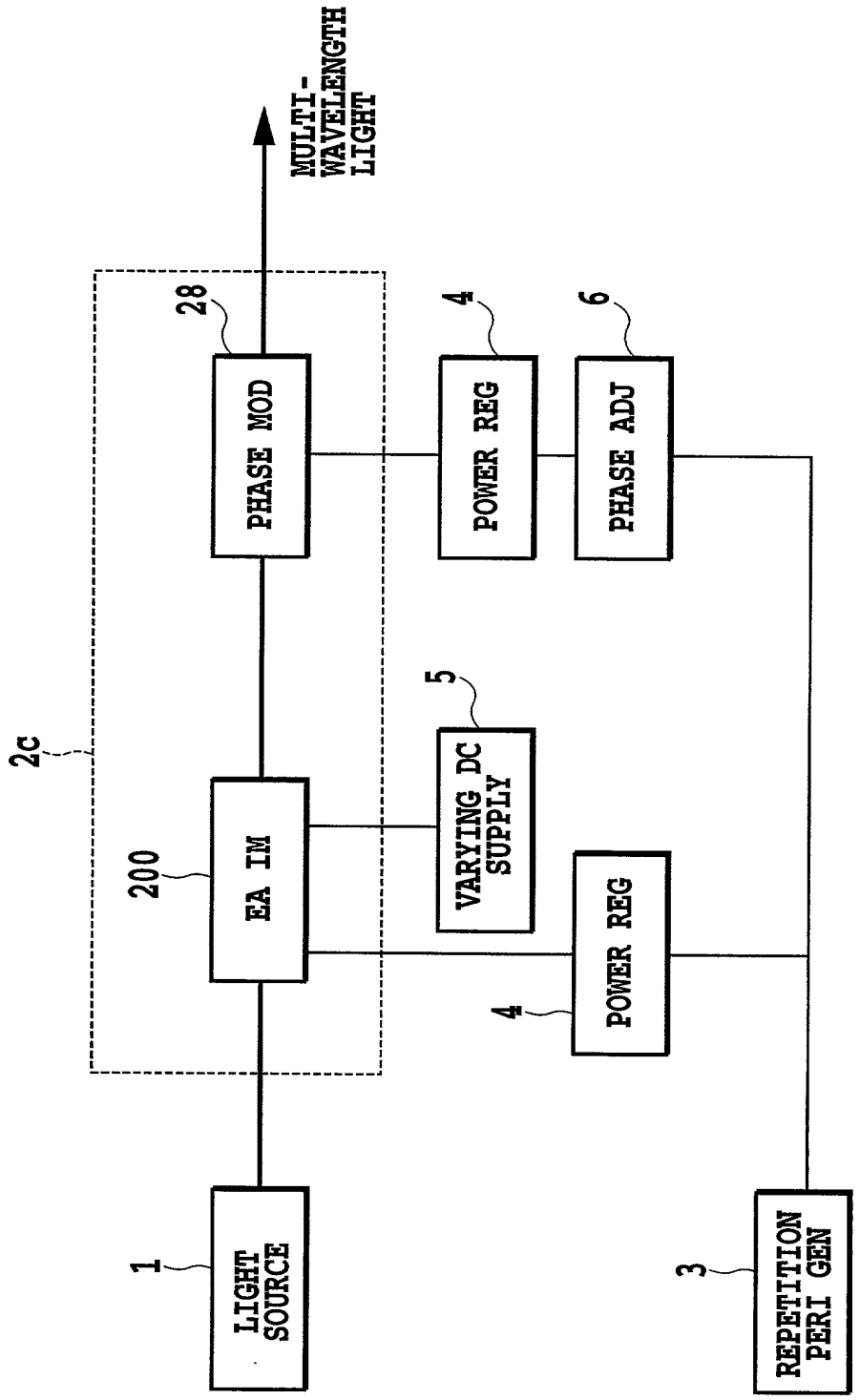

MULTI-
WAVELENGTH
LIGHT
28
PHASE MOD
4
POWER REG
6
PHASE ADJ
5
VARYING DC
SUPPLY
2c
200
EA IM
4
POWER REG
1
LIGHT
SOURCE
3
REPETITION
PERI GEN

FIG.39

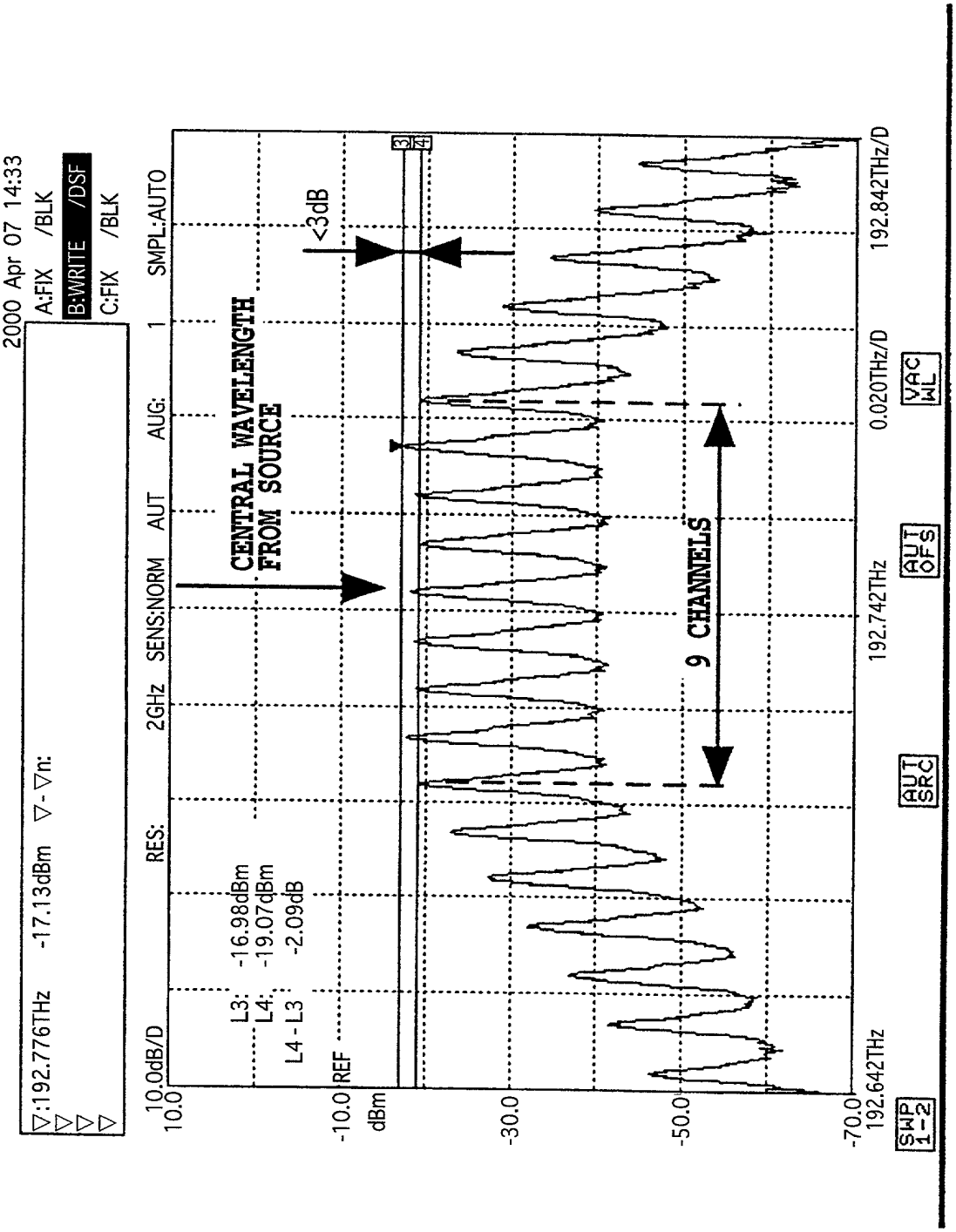

EXPERIMENTAL RESULT USING EA IM
2000 Apr 07 14:33
A:FIX /BLK
B:WRITE /DSF
C:FIX /BLK
▽:192.776THz -17.13dBm ▽-▽n:
10.0dB/D RES: 2GHz SENS:NORM AUT AUG: 1 SMPL:AUTO
L3: -16.98dBm
L4: -19.07dBm
L4 - L3 -2.09dB
REF
10.0
-10.0
dBm
-30.0
-50.0
-70.0
CENTRAL WAVELENGTH FROM SOURCE
<3dB
9 CHANNELS
192.642THz
192.742THz
0.020THz/D
192.842THz/D
SWP 1-2
AUT SRC
AUT OFS
VAC WL

FIG.40

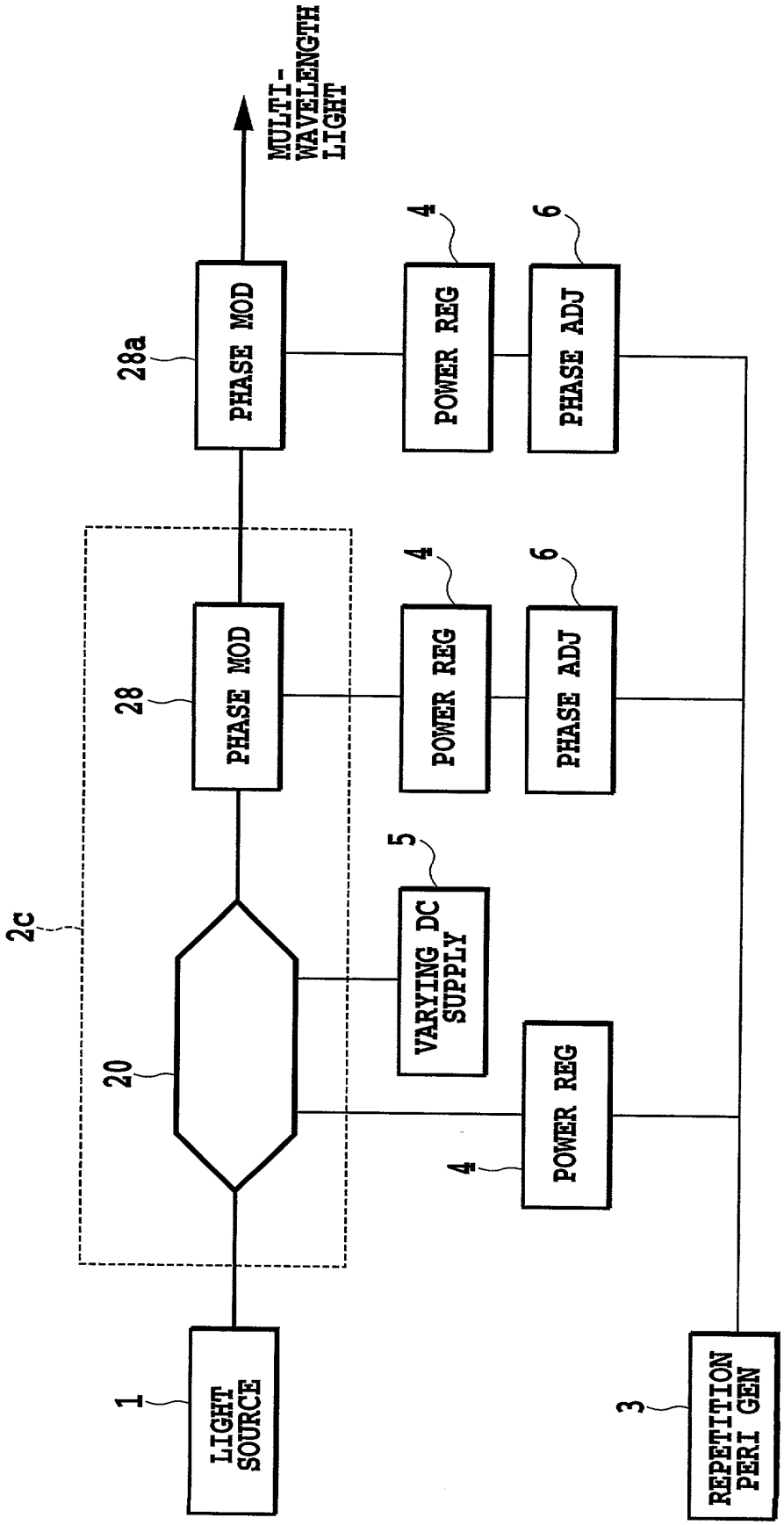

MULTI-WAVELENGTH LIGHT
28a
PHASE MOD
4
POWER REG
6
PHASE ADJ
28
PHASE MOD
4
POWER REG
6
PHASE ADJ
2c
5
VARYING DC SUPPLY
20
4
POWER REG
1
LIGHT SOURCE
3
REPETITION PERI GEN

FIG.41

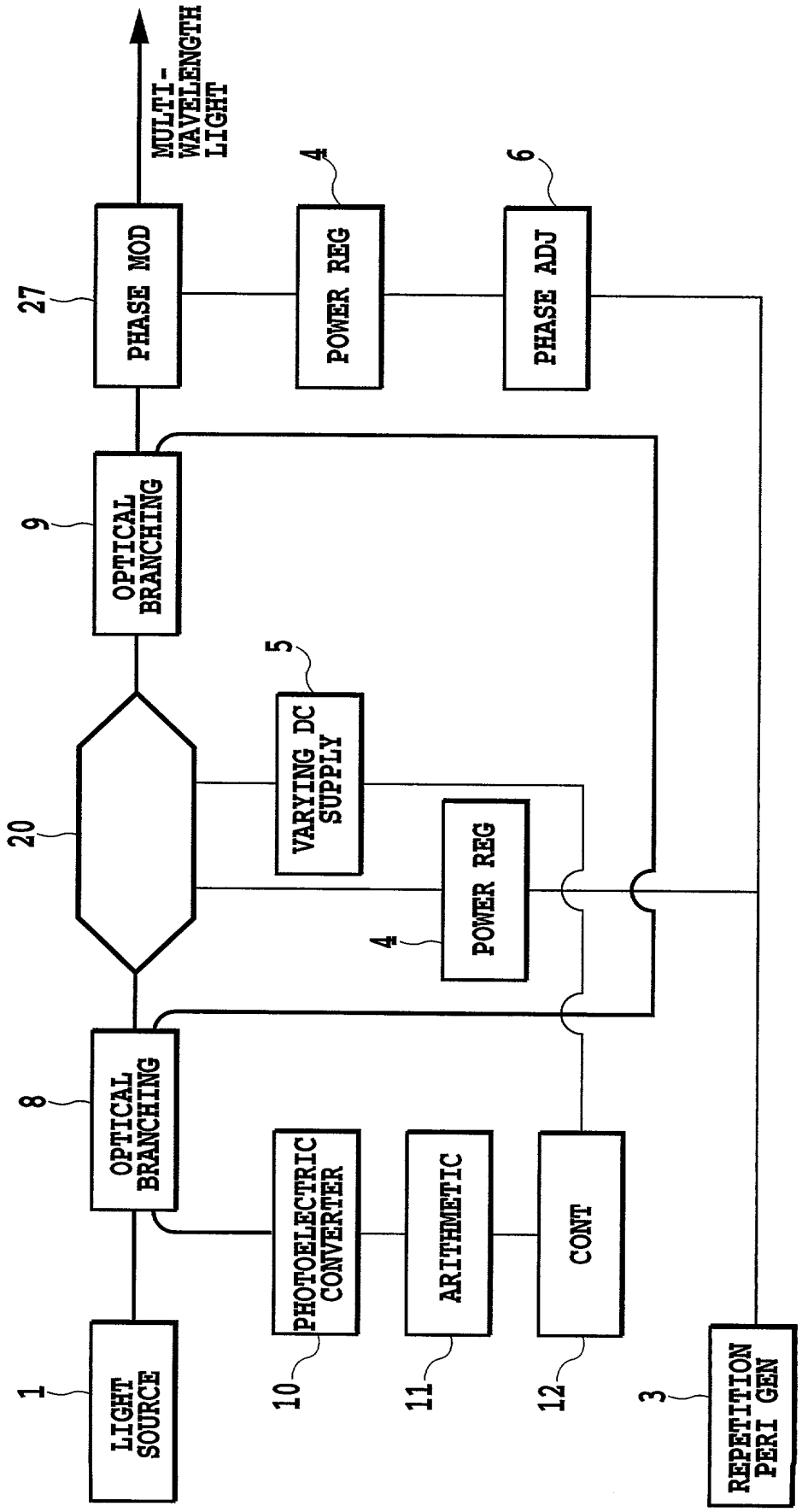

MULTI-WAVELENGTH LIGHT
PHASE MOD
27
POWER REG
4
PHASE ADJ
6
OPTICAL BRANCHING
9
VARYING DC SUPPLY
5
20
POWER REG
4
OPTICAL BRANCHING
8
PHOTOELECTRIC CONVERTER
10
ARITHMETIC
11
CONT
12
LIGHT SOURCE
1
REPETITION PERI GEN
3

FIG.42

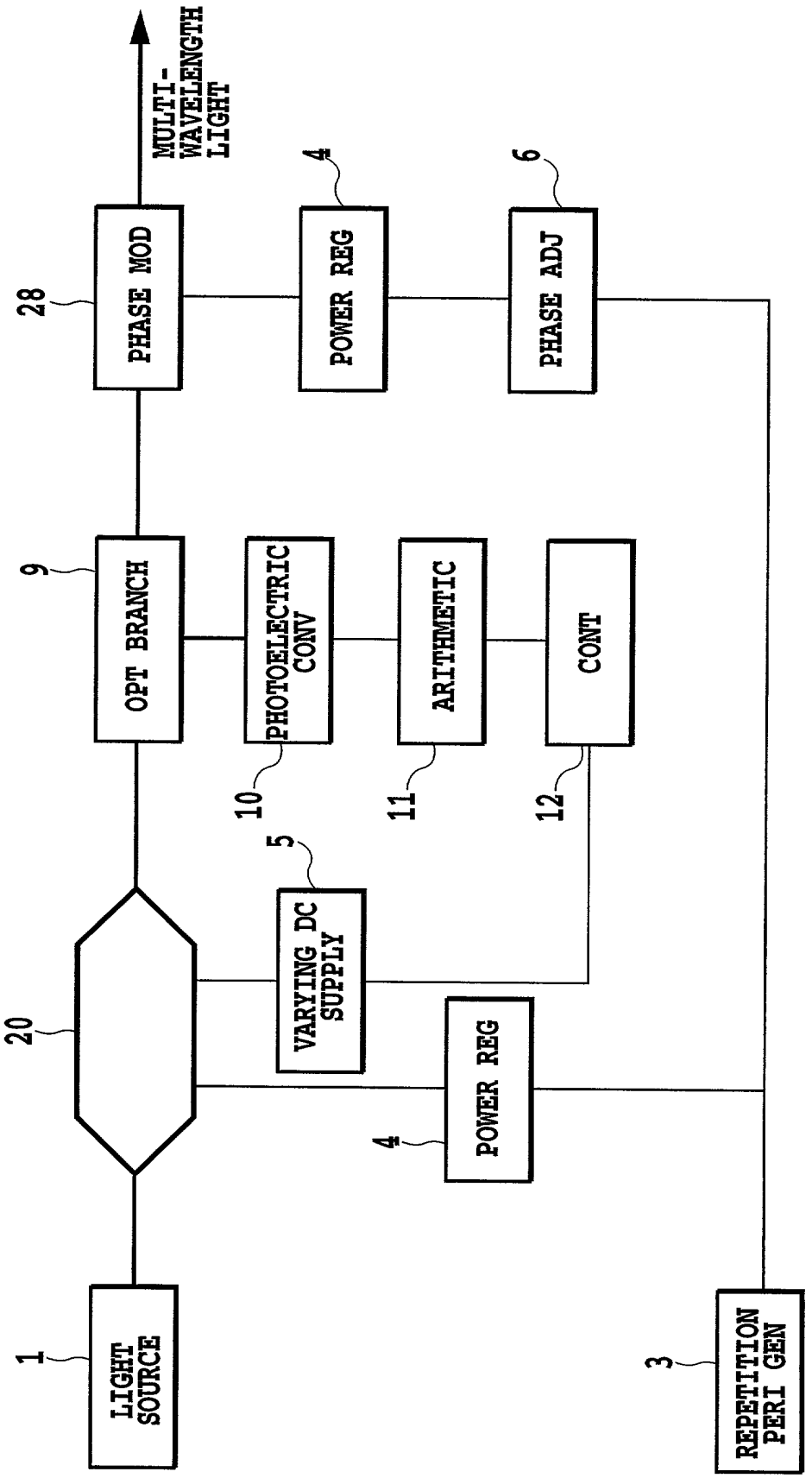

MULTI-WAVELENGTH LIGHT
PHASE MOD
POWER REG
PHASE ADJ
OPT BRANCH
PHOTOELECTRIC CONV
ARITHMETIC
CONT
VARYING DC SUPPLY
POWER REG
LIGHT SOURCE
REPETITION PERI GEN
28
4
6
9
10
11
12
5
20
4
1
3

FIG.43

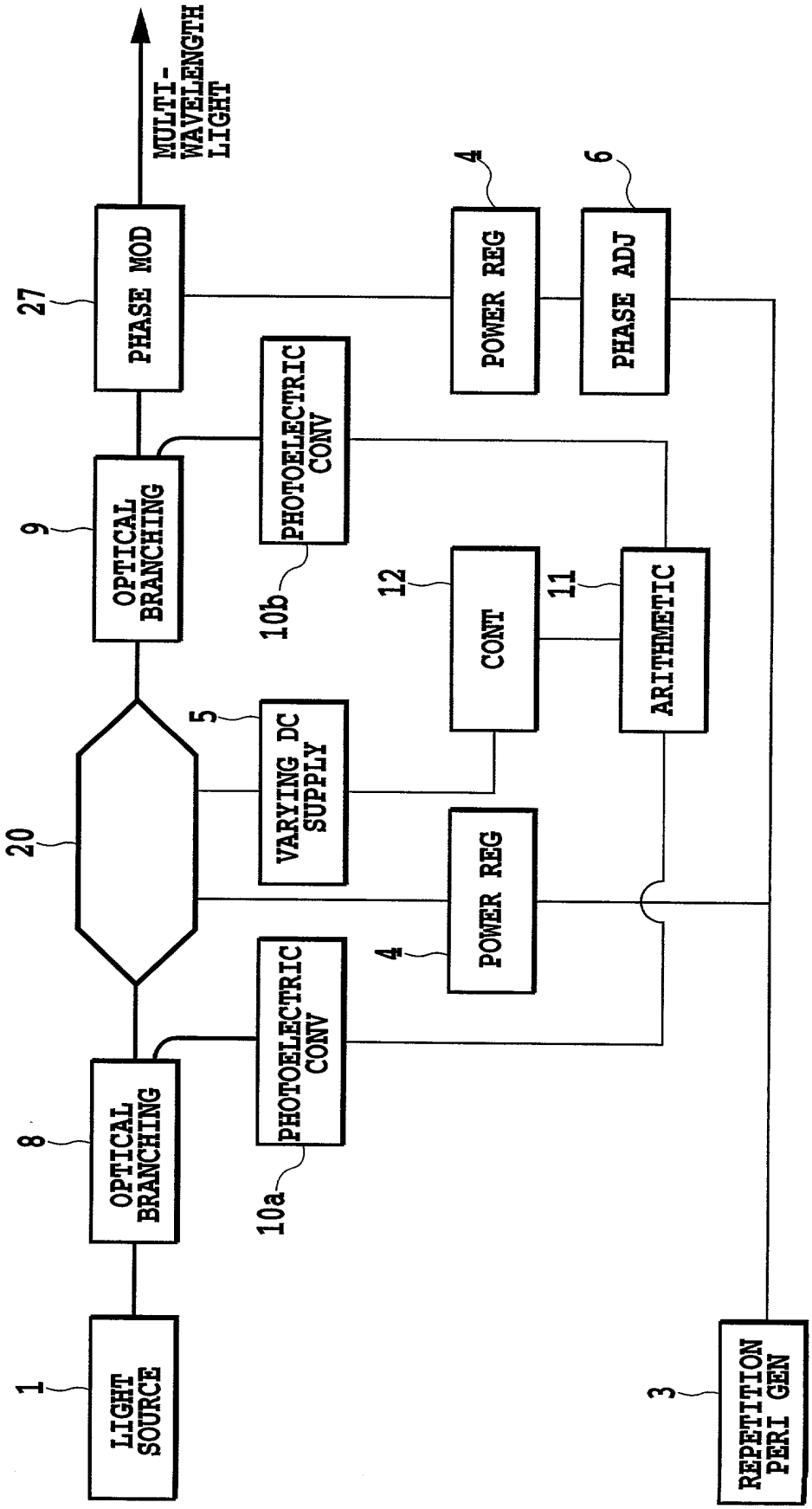

MULTI-WAVELENGTH LIGHT
PHASE MOD
27
POWER REG
4
PHASE ADJ
6
PHOTOELECTRIC CONV
10b
OPTICAL BRANCHING
9
CONT
12
ARITHMETIC
11
VARYING DC SUPPLY
5
20
POWER REG
4
PHOTOELECTRIC CONV
10a
OPTICAL BRANCHING
8
LIGHT SOURCE
1
REPETITION PERI GEN
3

FIG.44

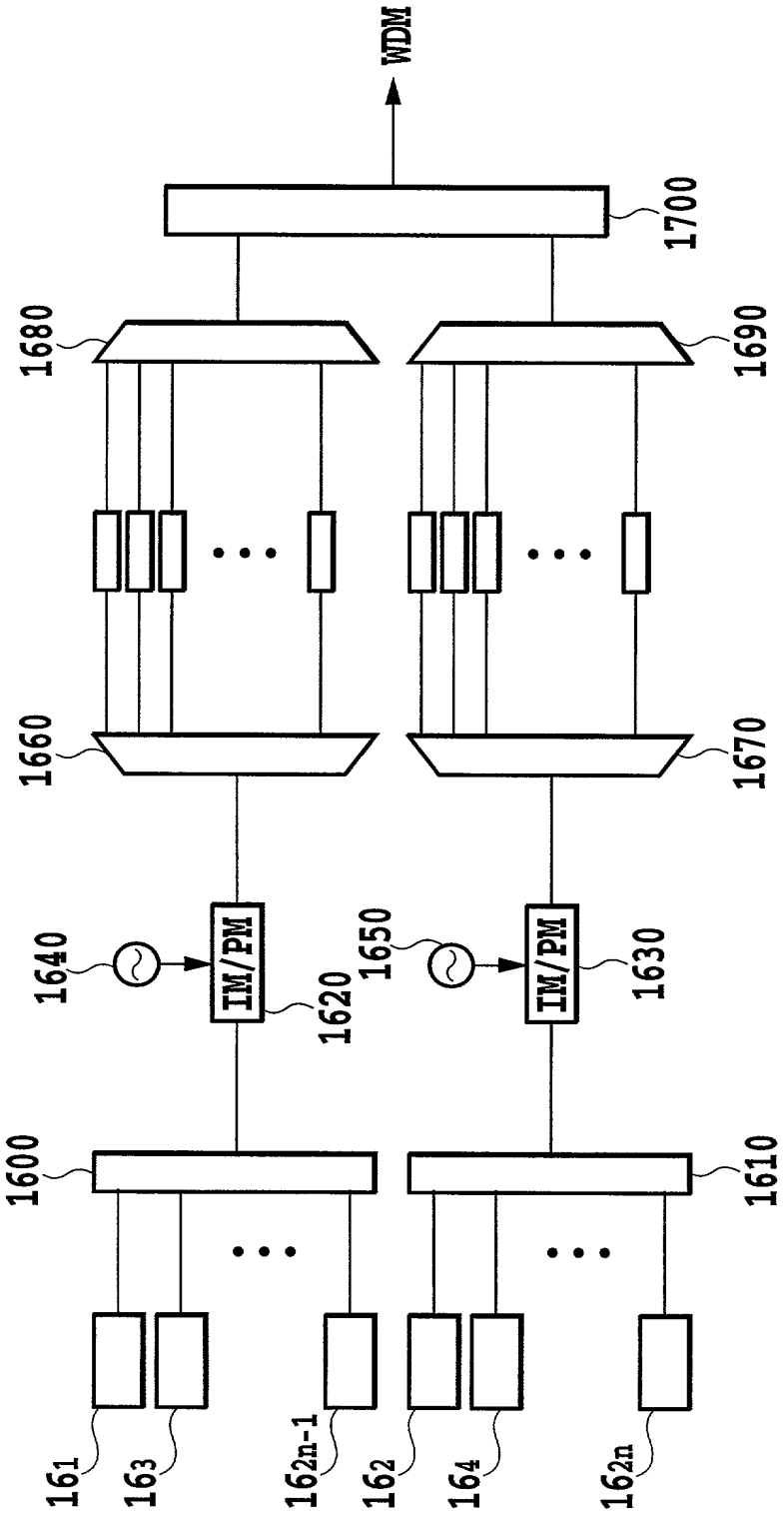

WDM
1700
1680
1690
1660
1670
1640
IM/PM
1620
1650
IM/PM
1630
1600
1610
161
163
162n-1
162
164
162n

FIG.45

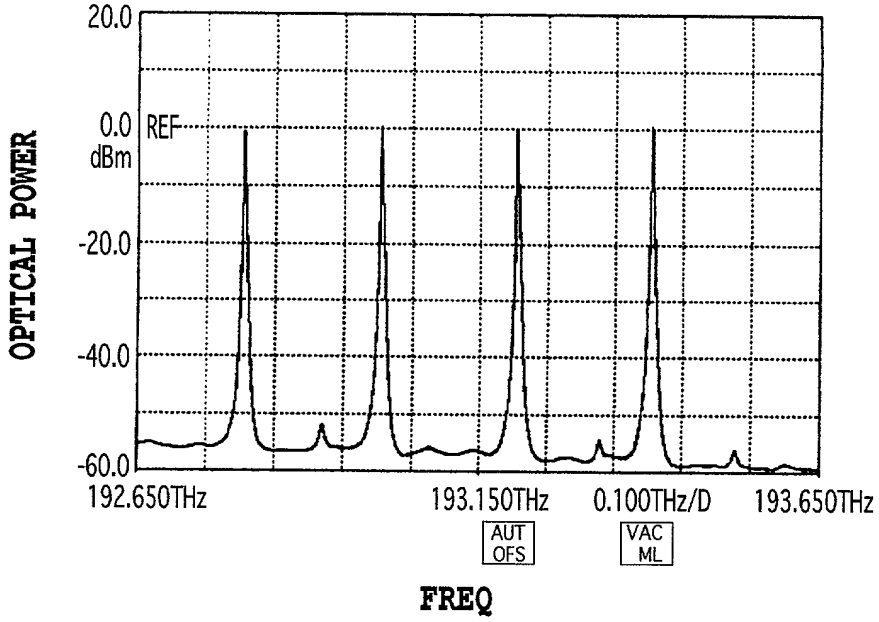


FIG.46A

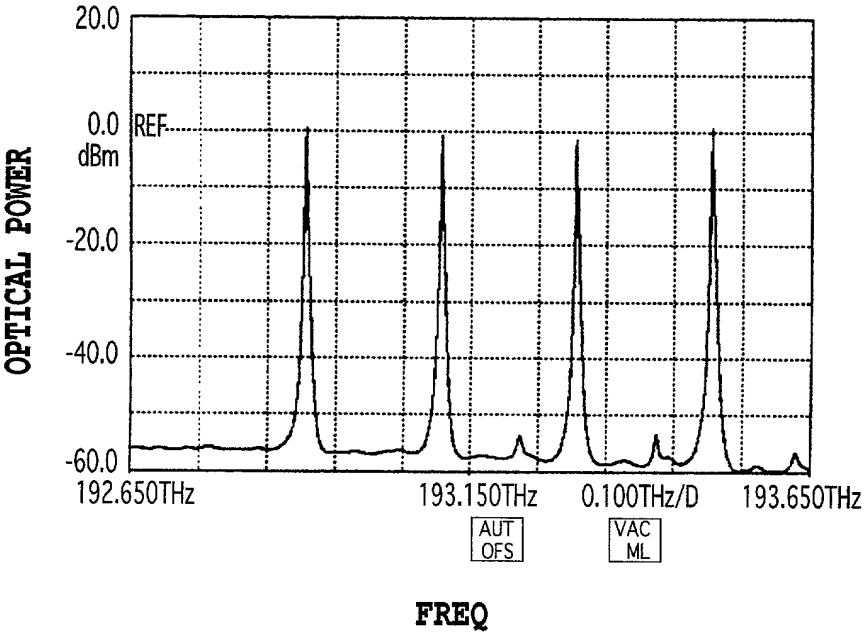


FIG.46B

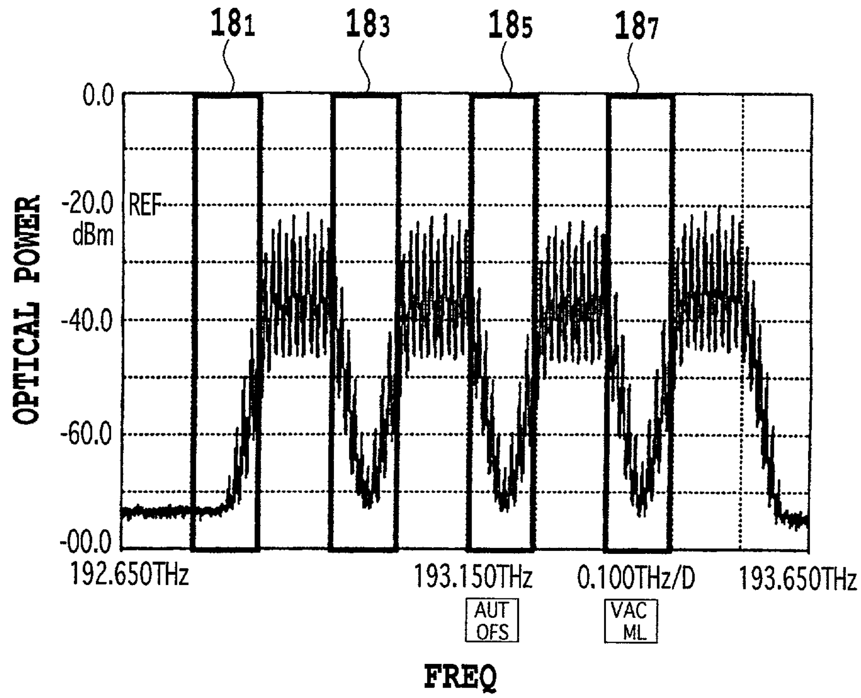


FIG.47A

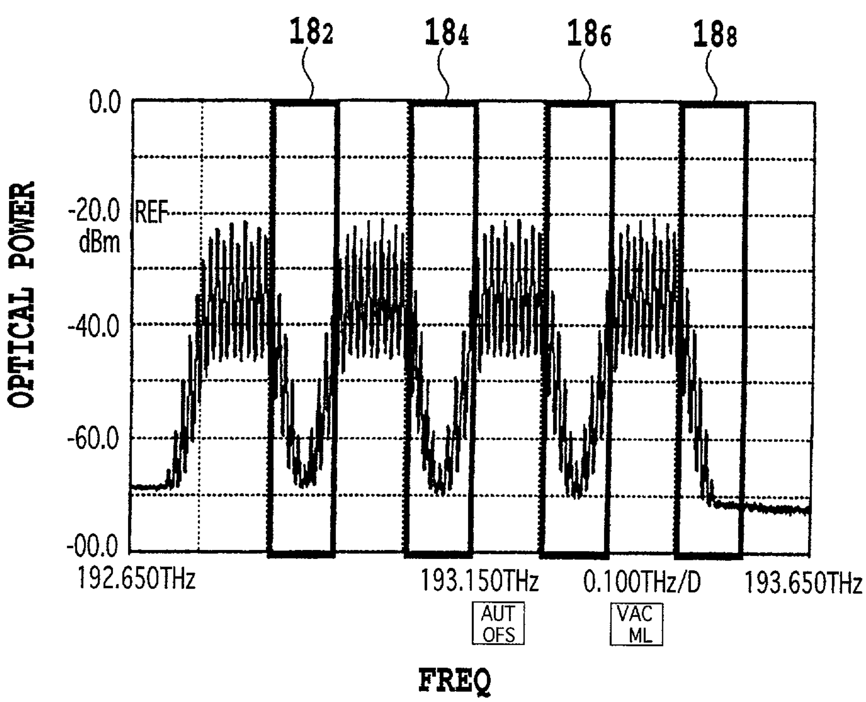


FIG.47B

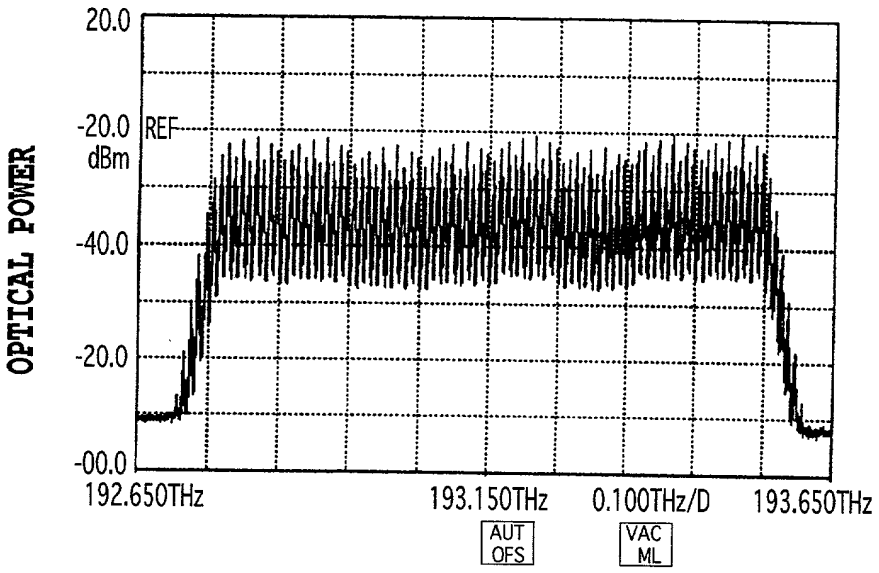

20.0
-20.0
dBm
REF
-40.0
-20.0
-00.0
OPTICAL POWER
192.650THz
193.150THz
AUT
OFS
0.100THz/D
VAC
ML
193.650THz
FREQ

FIG.48

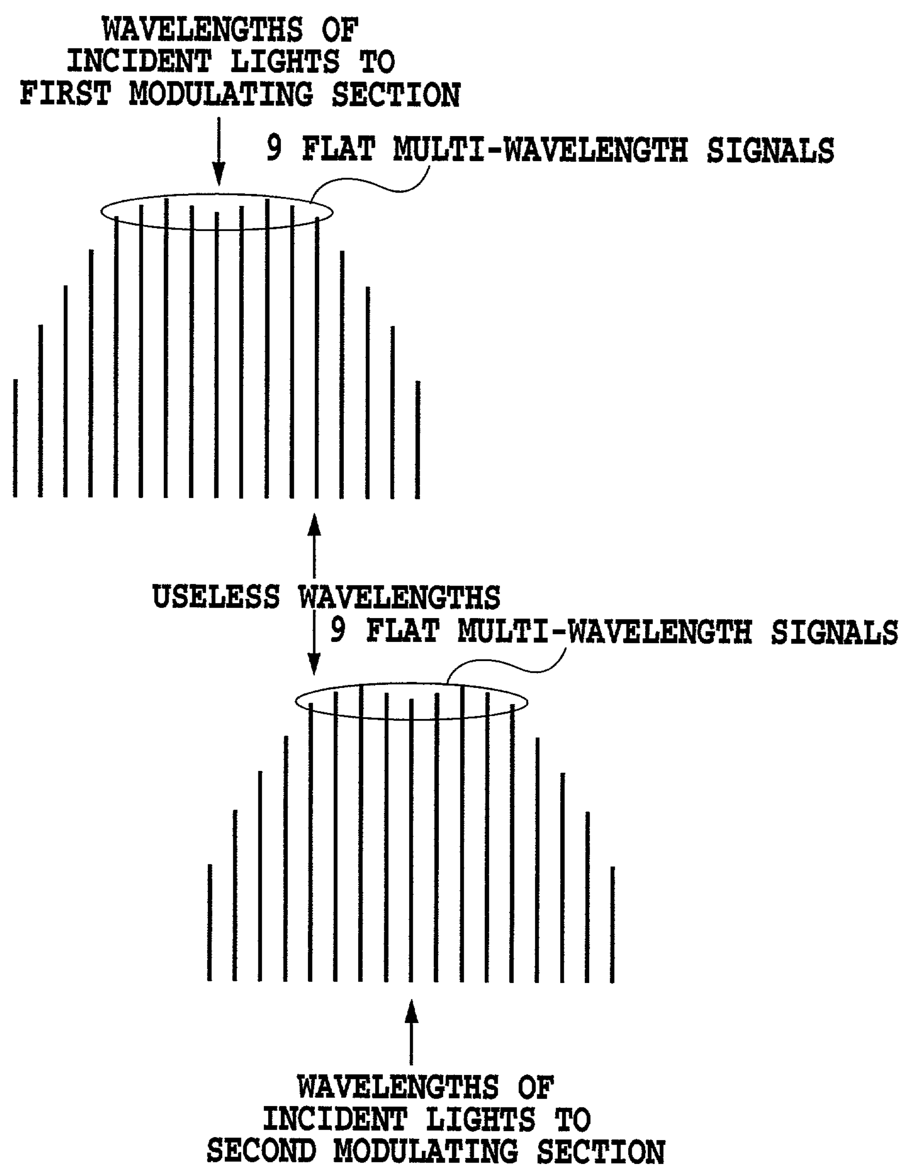


FIG.49A

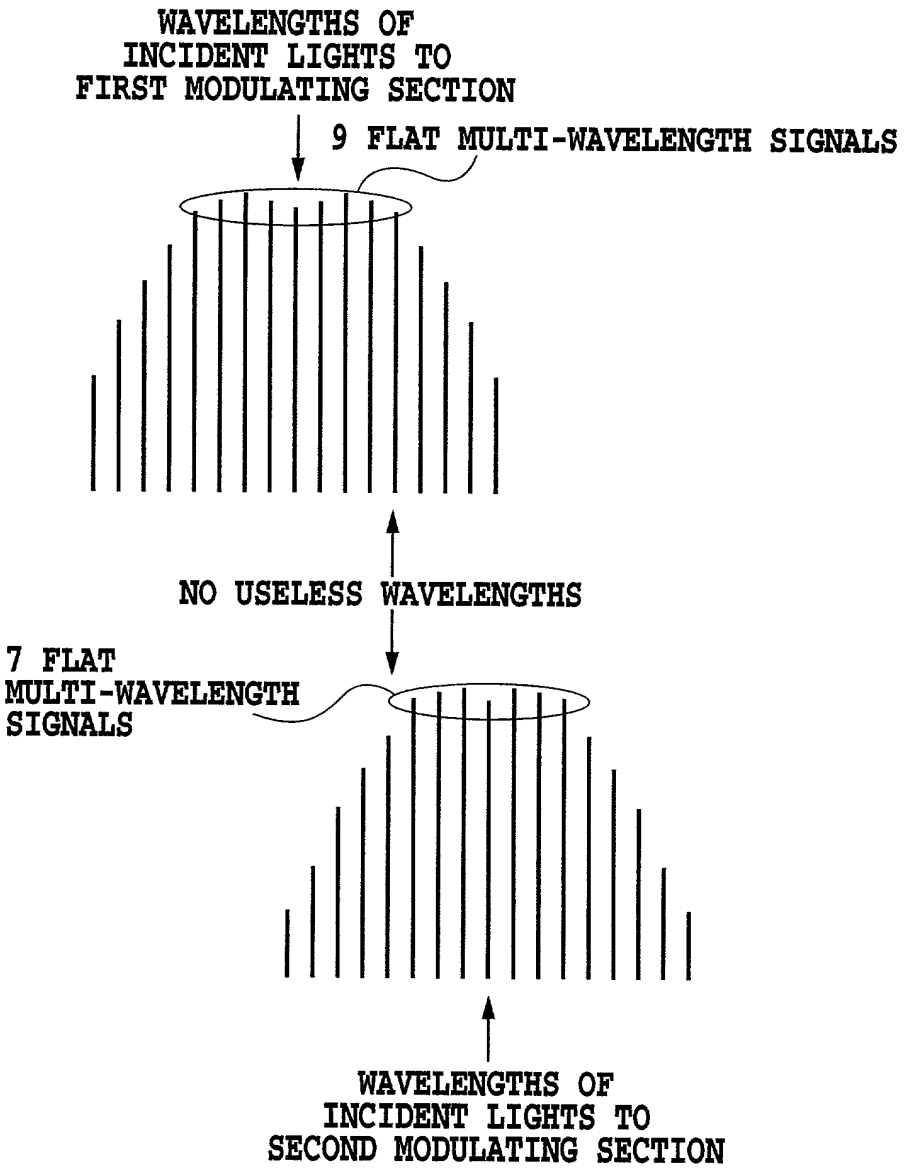


FIG.49B

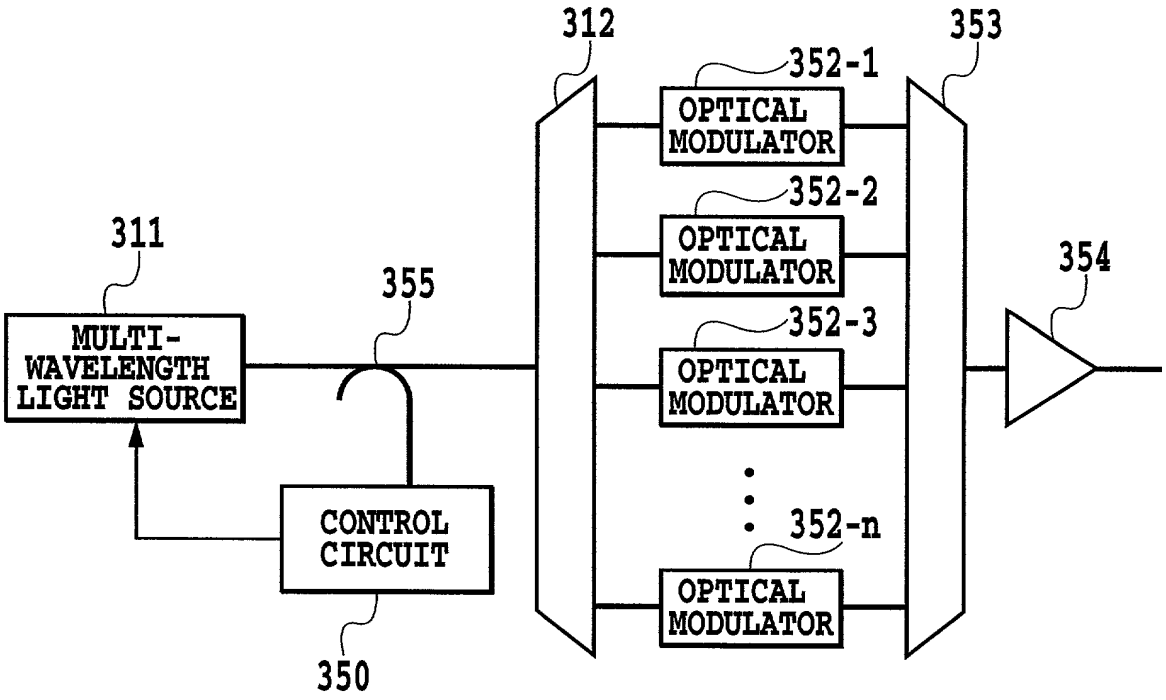

312
353
352-1
OPTICAL MODULATOR
352-2
OPTICAL MODULATOR
311
355
354
MULTI-WAVELENGTH LIGHT SOURCE
352-3
OPTICAL MODULATOR
352-n
OPTICAL MODULATOR
CONTROL CIRCUIT
350

FIG.50

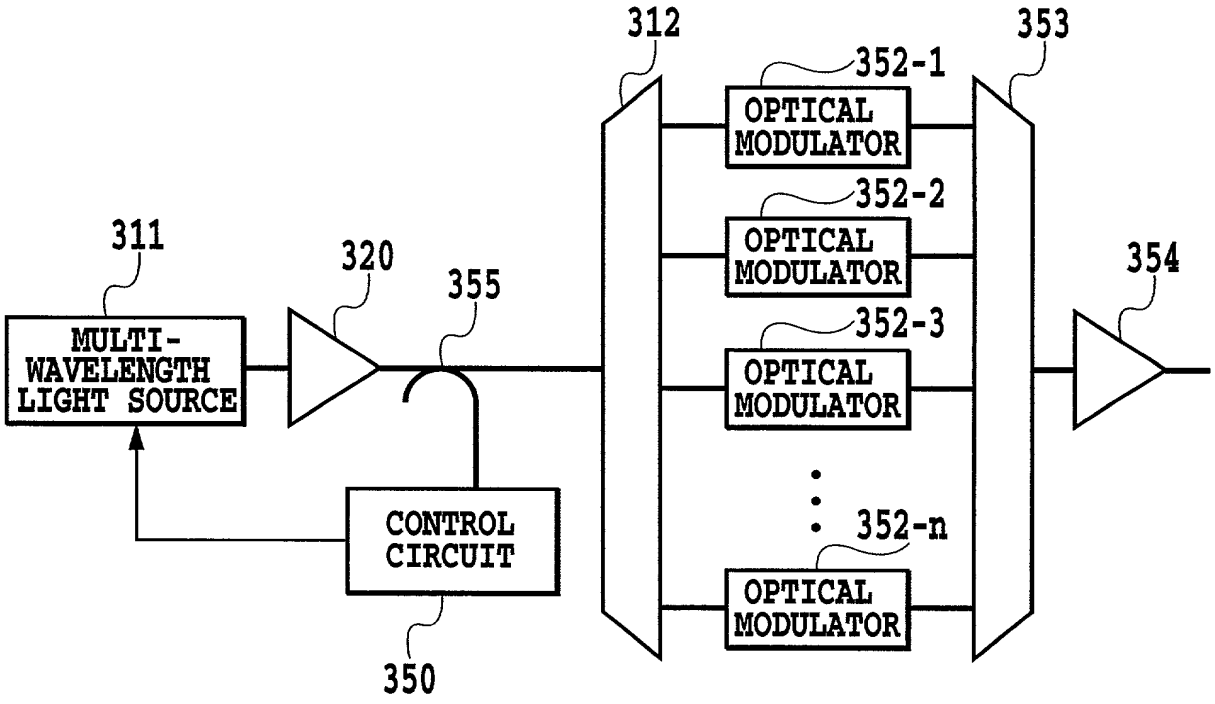

312
353
352-1
OPTICAL MODULATOR
352-2
OPTICAL MODULATOR
311
320
355
354
MULTI-WAVELENGTH LIGHT SOURCE
352-3
OPTICAL MODULATOR
352-n
OPTICAL MODULATOR
CONTROL CIRCUIT
350

FIG.51

WAVELENGTH-MULTIPLEXED TRANSMISSION SYSTEM USING
COHERENT MULTI-WAVELENGTH SIGNAL GENERATING APPARATUS

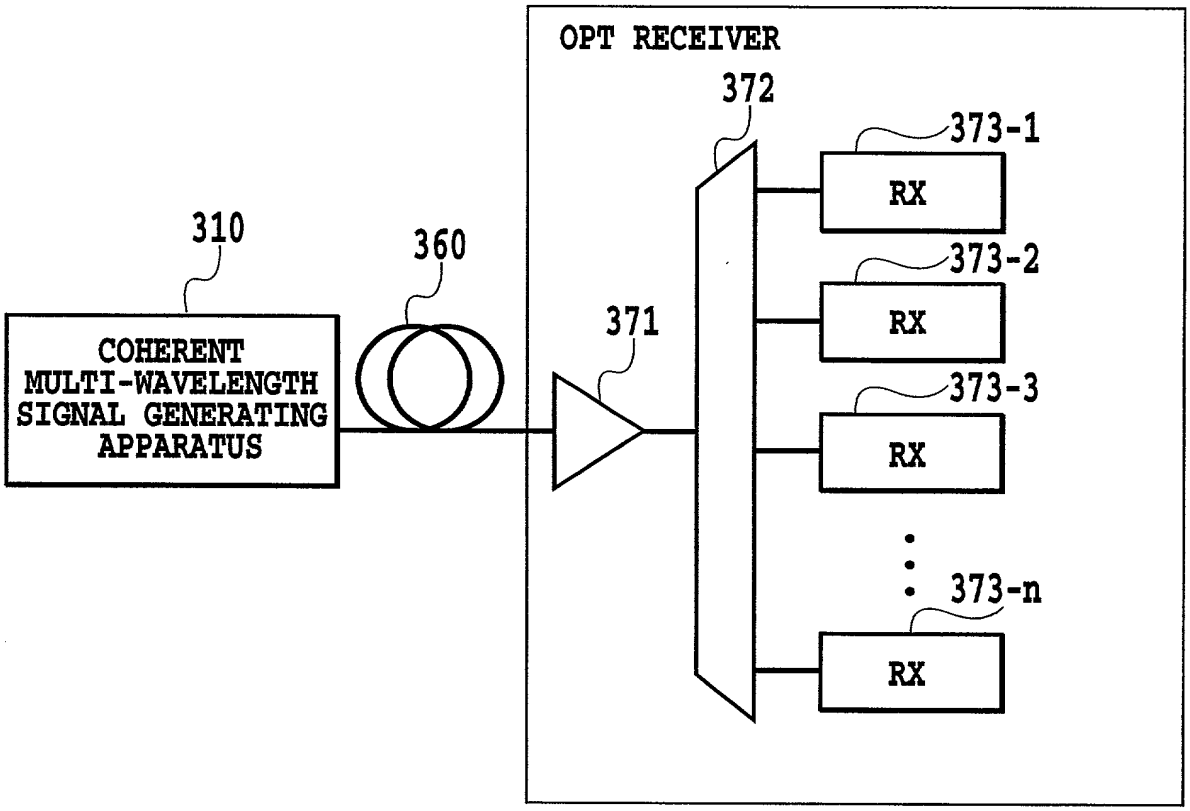


FIG.52

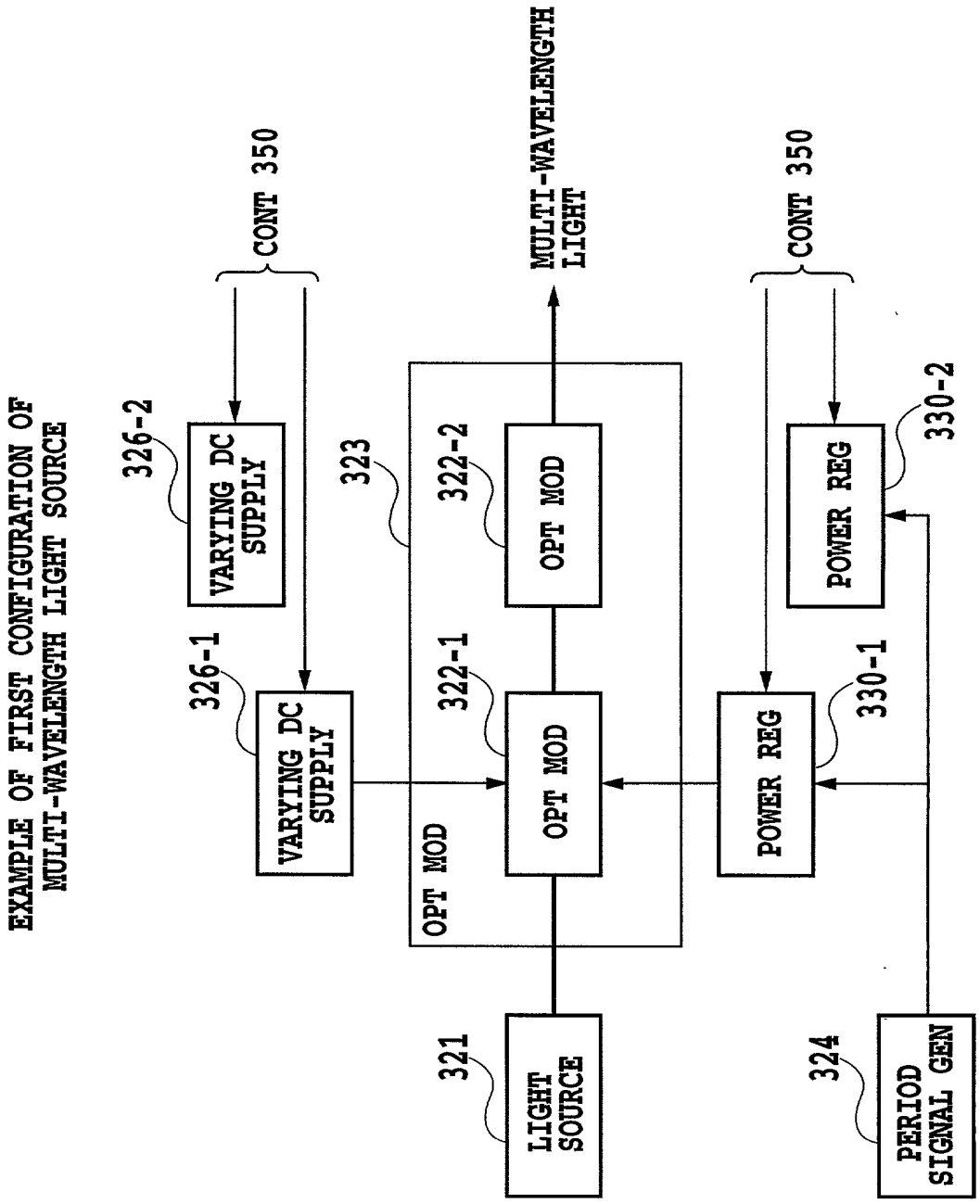
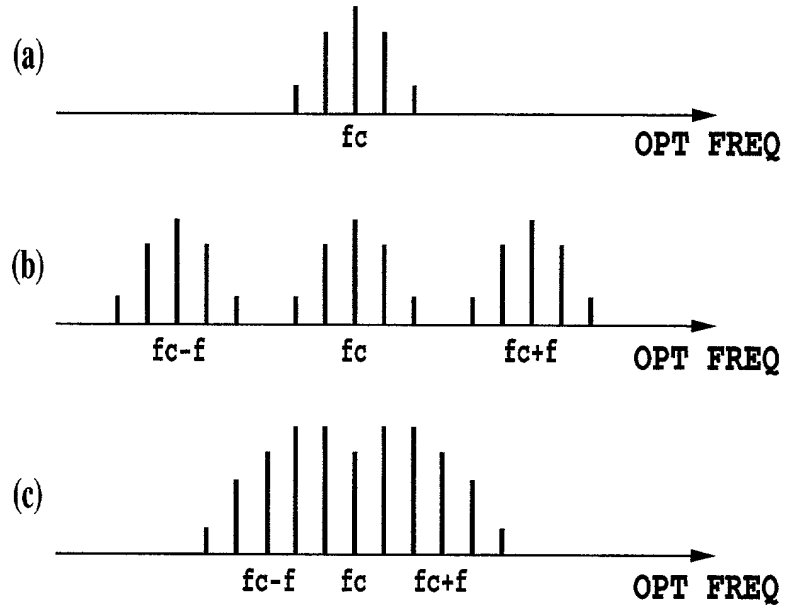

EXAMPLE OF FIRST CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE
CONT 350
CONT 350
MULTI-WAVELENGTH LIGHT
326-2
VARYING DC SUPPLY
326-1
VARYING DC SUPPLY
323
322-2
OPT MOD
322-1
OPT MOD
OPT MOD
330-2
POWER REG
330-1
POWER REG
321
LIGHT SOURCE
324
PERIOD SIGNAL GEN

FIG.53

FIG. 53 PRINCIPLE OF GENERATION OF MULTI-WAVELENGTH LIGHT FROM MULTI-WAVELENGTH LIGHT SOURCE

FIG.54



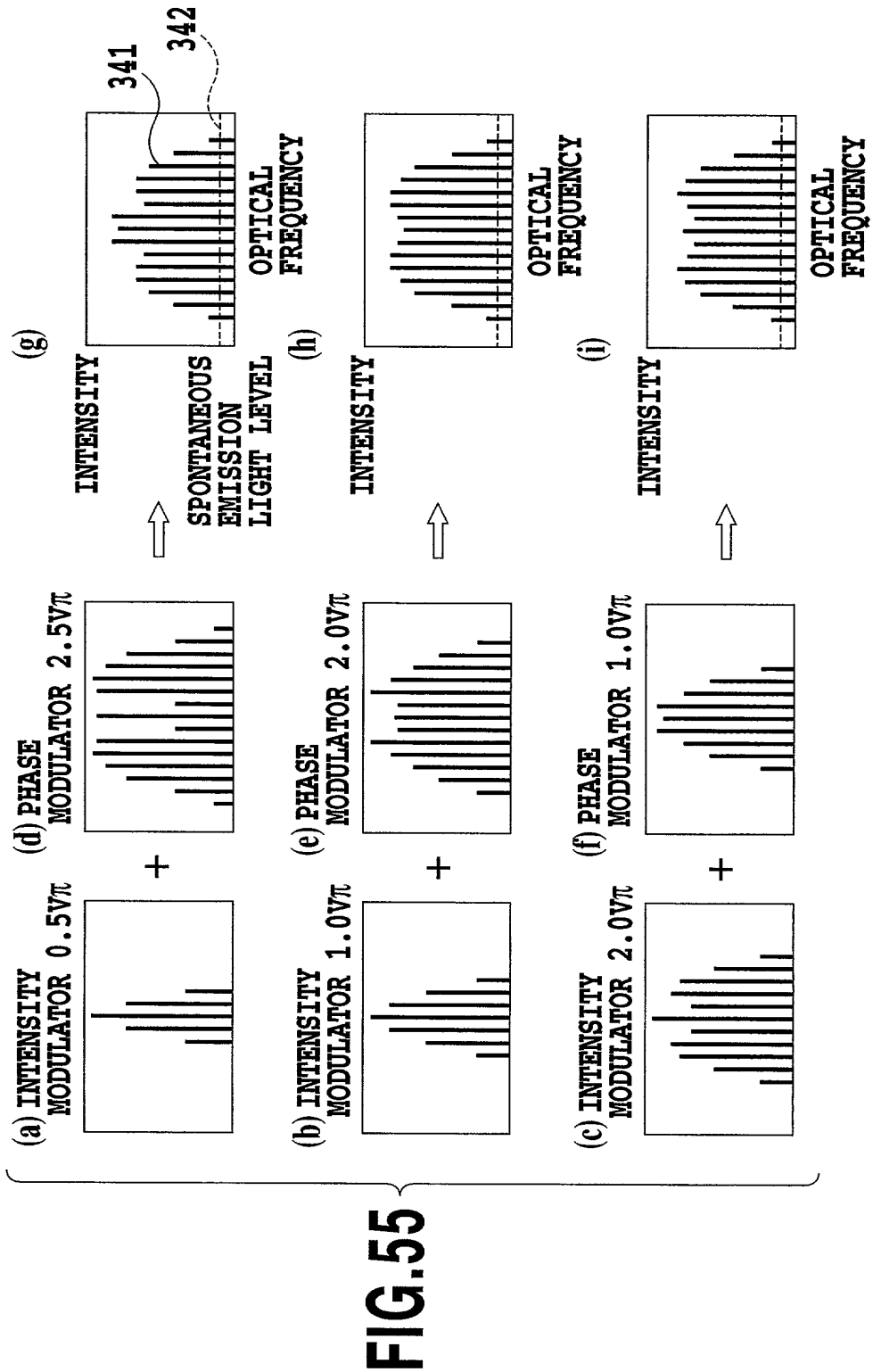

SHAPE CONTROL OF OPTICAL SPECTRUM USING INTENSITY AND PHASE MODULATORS AS OPTICAL MODULATING SECTION
(a) INTENSITY MODULATOR 0.5Vπ
(b) INTENSITY MODULATOR 1.0Vπ
(c) INTENSITY MODULATOR 2.0Vπ
(d) PHASE MODULATOR 2.5Vπ
(e) PHASE MODULATOR 2.0Vπ
(f) PHASE MODULATOR 1.0Vπ
(g)
(h)
(i)
INTENSITY
OPTICAL FREQUENCY
SPONTANEOUS EMISSION LIGHT LEVEL
341
342

FIG.55

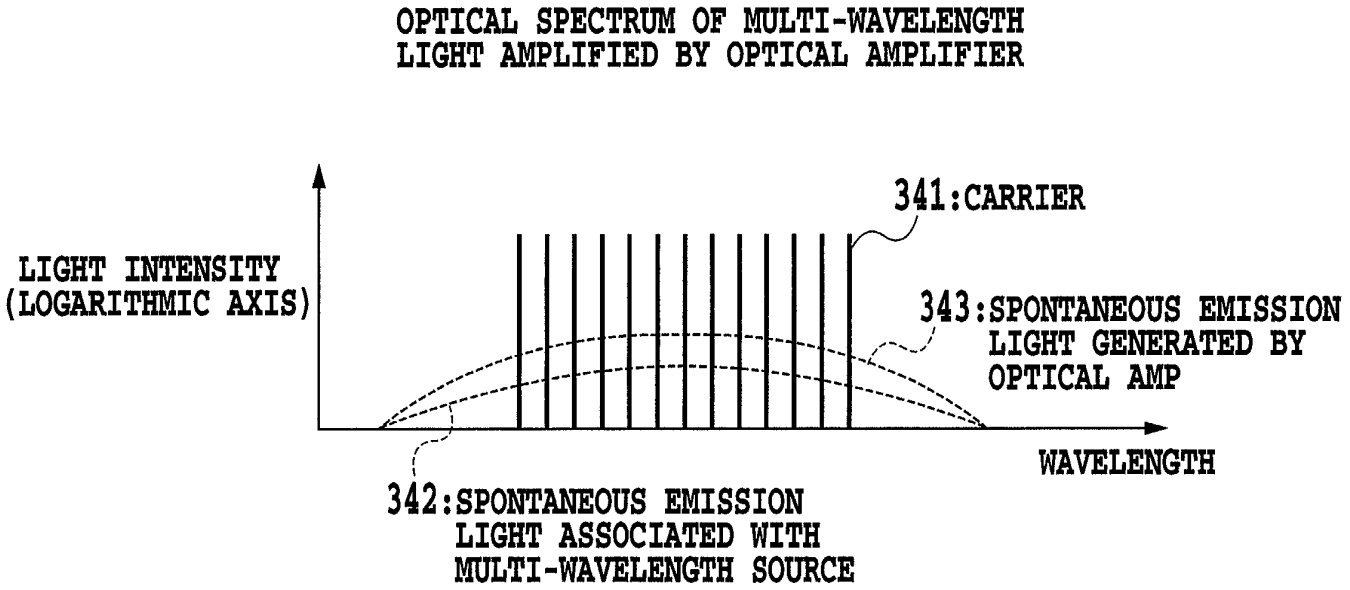


FIG.56

EXAMPLE OF SECOND CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE

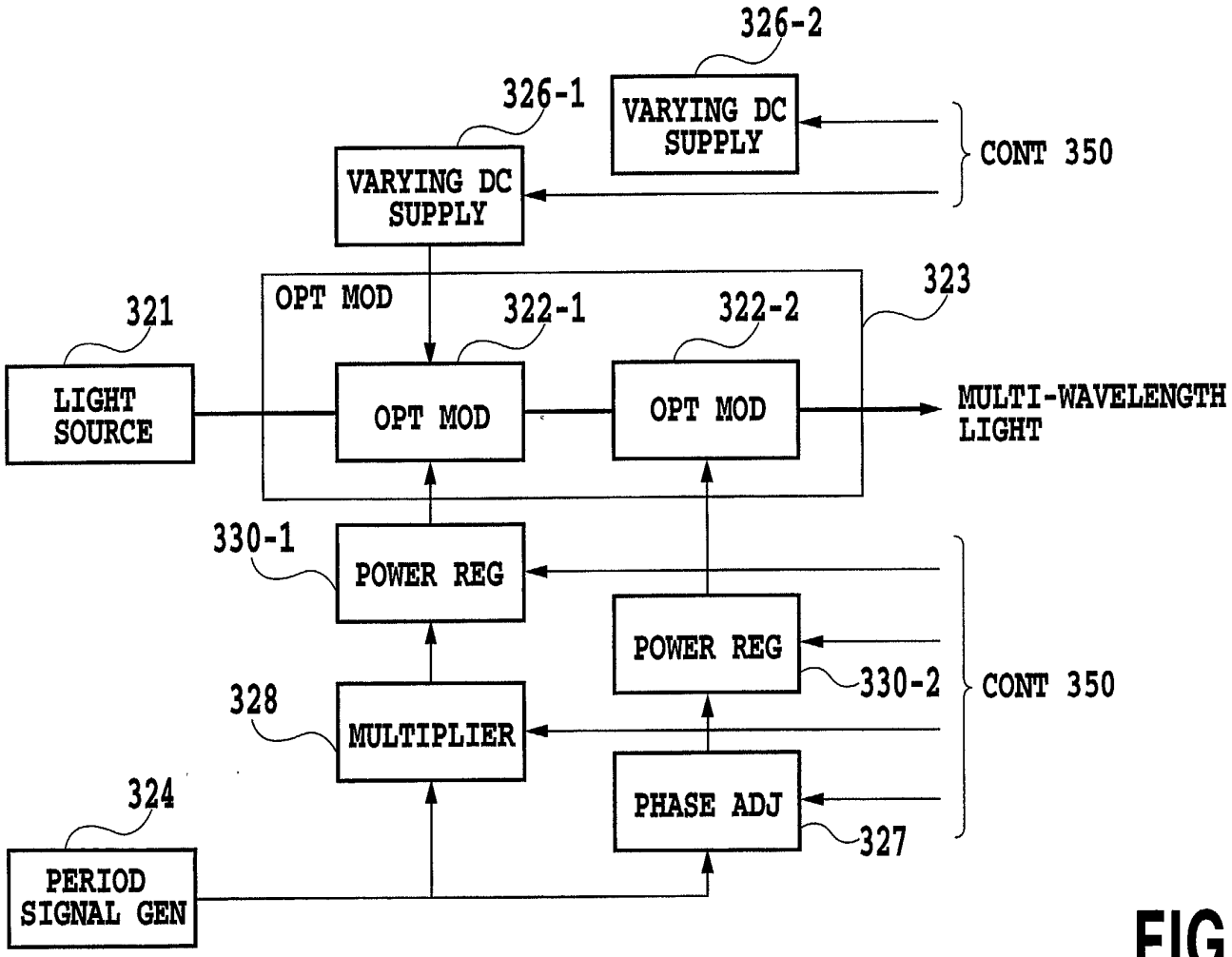


FIG.57

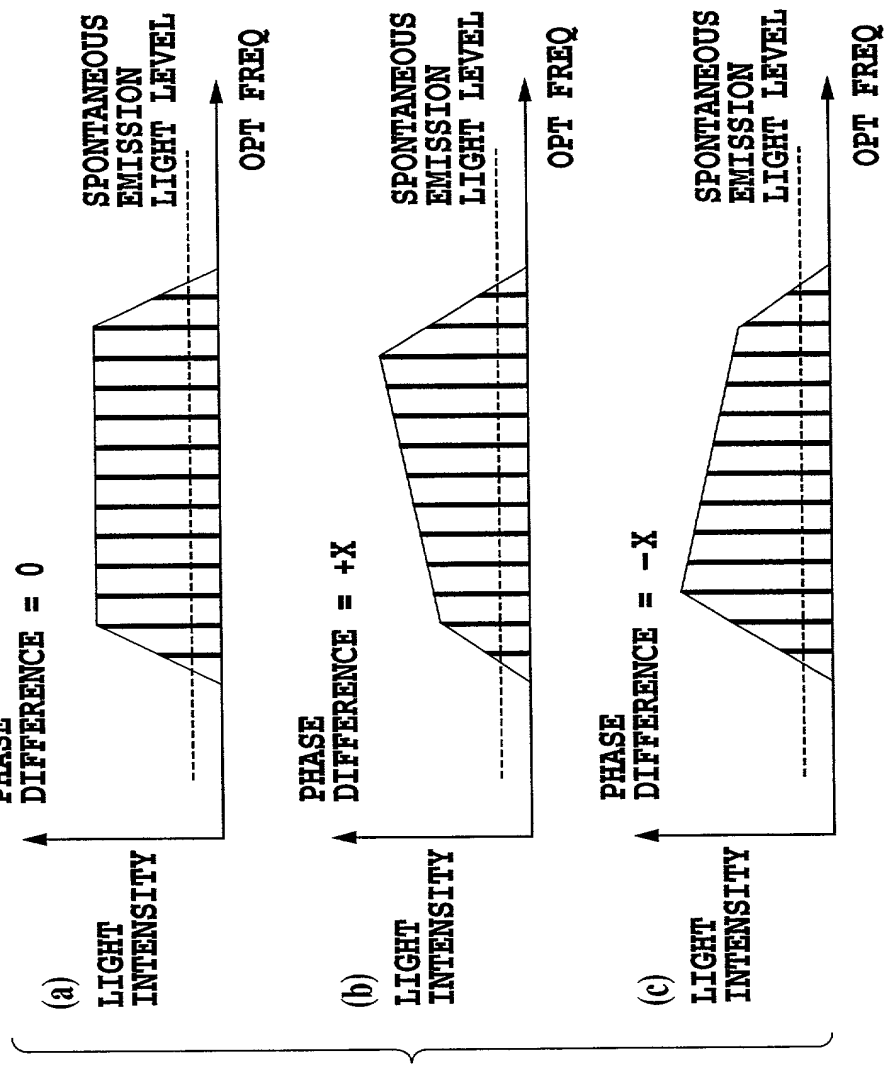
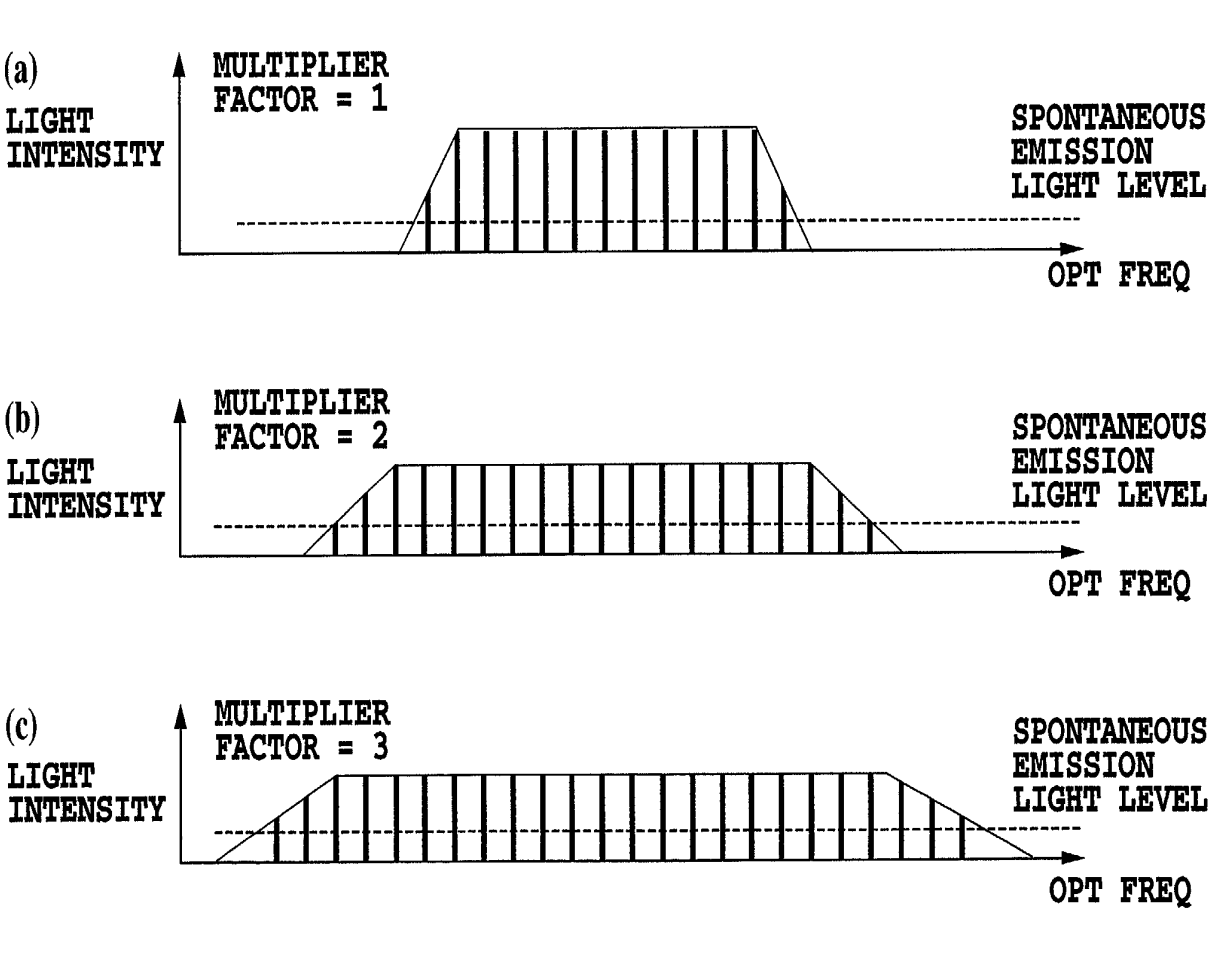

SHAPE CONTROL OF OPTICAL SPECTRUM
BY REGULATING PHASES OF PERIOD SIGNALS
(a)
PHASE
DIFFERENCE = 0
LIGHT
INTENSITY
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ
(b)
PHASE
DIFFERENCE = +X
LIGHT
INTENSITY
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ
(c)
PHASE
DIFFERENCE = -X
LIGHT
INTENSITY
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ

FIG.58

FIG.59


SHAPE CONTROL OF OPTICAL SPECTRUM
BY REGULATING PERIOD SIGNALS
(a)
LIGHT INTENSITY
MULTIPLIER FACTOR = 1
SPONTANEOUS EMISSION LIGHT LEVEL
OPT FREQ
(b)
LIGHT INTENSITY
MULTIPLIER FACTOR = 2
SPONTANEOUS EMISSION LIGHT LEVEL
OPT FREQ
(c)
LIGHT INTENSITY
MULTIPLIER FACTOR = 3
SPONTANEOUS EMISSION LIGHT LEVEL
OPT FREQ

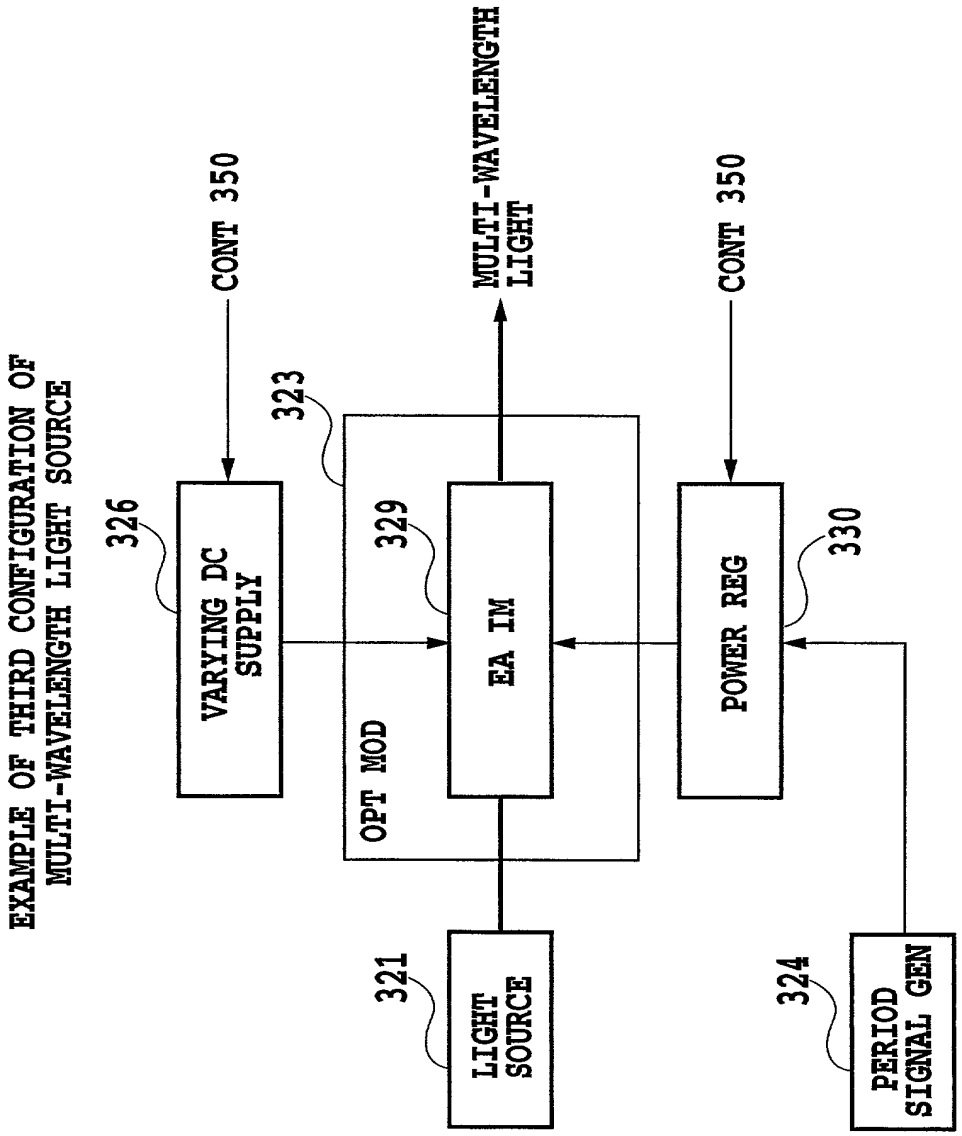

EXAMPLE OF THIRD CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE
CONT 350
MULTI-WAVELENGTH LIGHT
CONT 350
323
326
329
330
VARYING DC SUPPLY
EA IM
POWER REG
OPT MOD
321
324
LIGHT SOURCE
PERIOD SIGNAL GEN

FIG.60

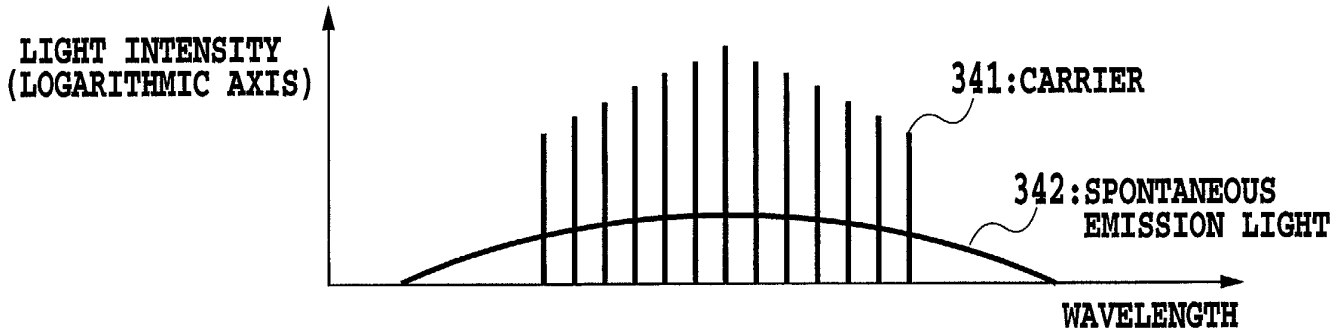

LIGHT INTENSITY
(LOGARITHMIC AXIS)
341:CARRIER
342:SPONTANEOUS
EMISSION LIGHT
WAVELENGTH

FIG.61

FOURTH EXAMPLE OF CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE

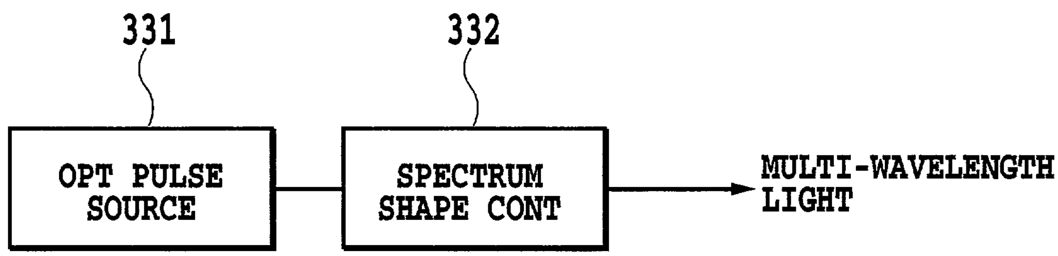


FIG.62

PRINCIPLE OF ADIABATIC COMPRESSION
WITH DISPERSION REDUCING FIBER

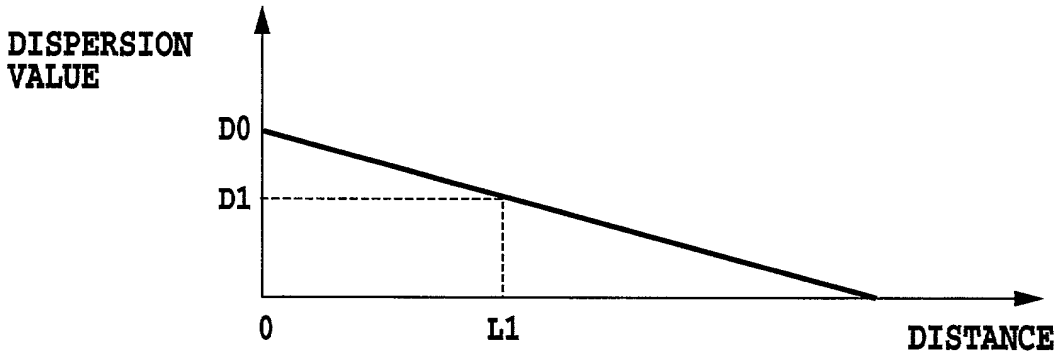
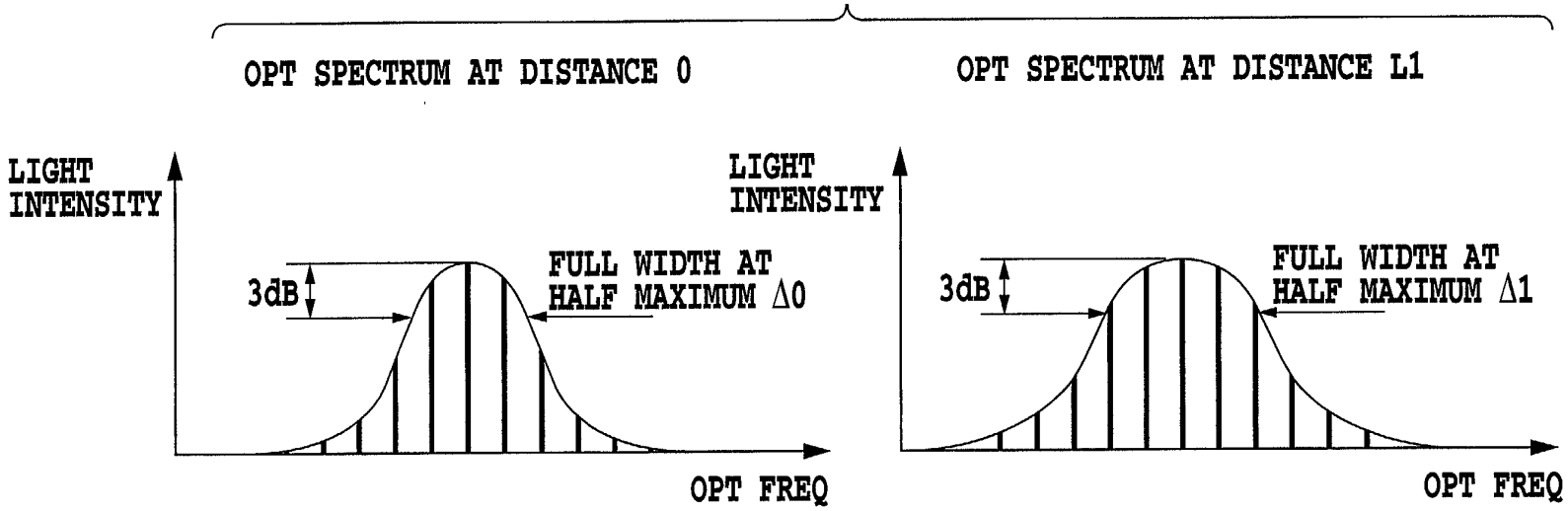


FIG.63A



$\Delta 1 / \Delta 0 = D0 / D1$

FIG.63B

RELATIONSHIP BETWEEN OPTICAL SPECTRUM OF COHERENT COMPONENTS OF MULTI-WAVELENGTH LIGHT AND TRANSMISSION CHARACTERISTIC OF DEMULTIPLEXER

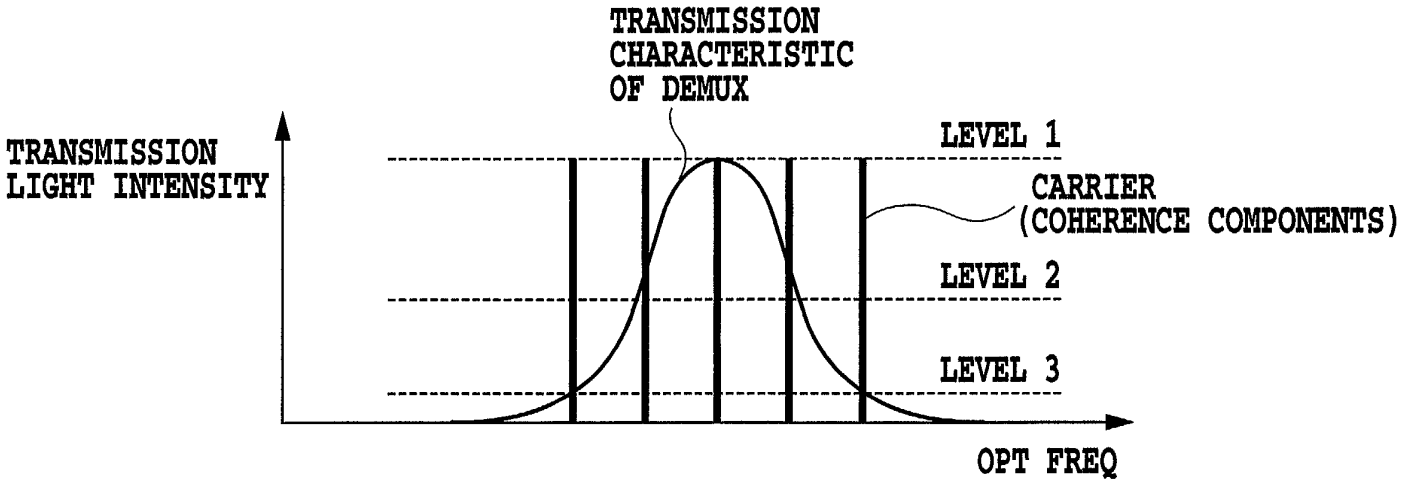


FIG.64

RELATIONSHIP BETWEEN STIMULATED EMISSION LIGHT AND SPONTANEOUS EMISSION LIGHT FROM SEMICONDUCTOR LASER

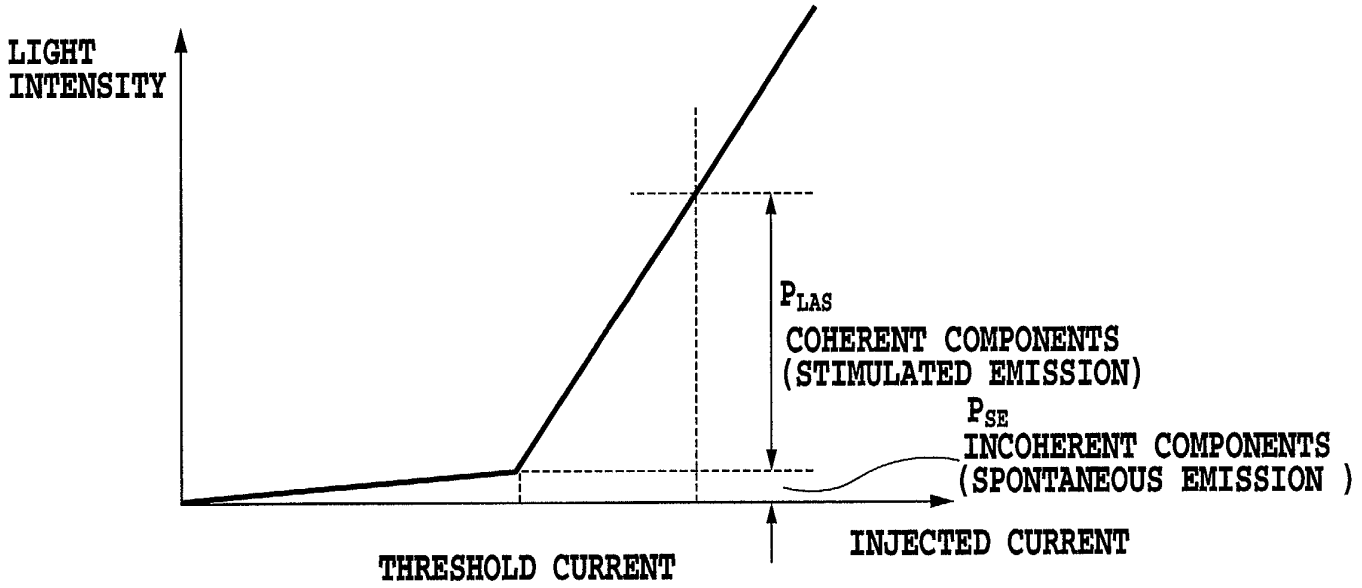


FIG.65

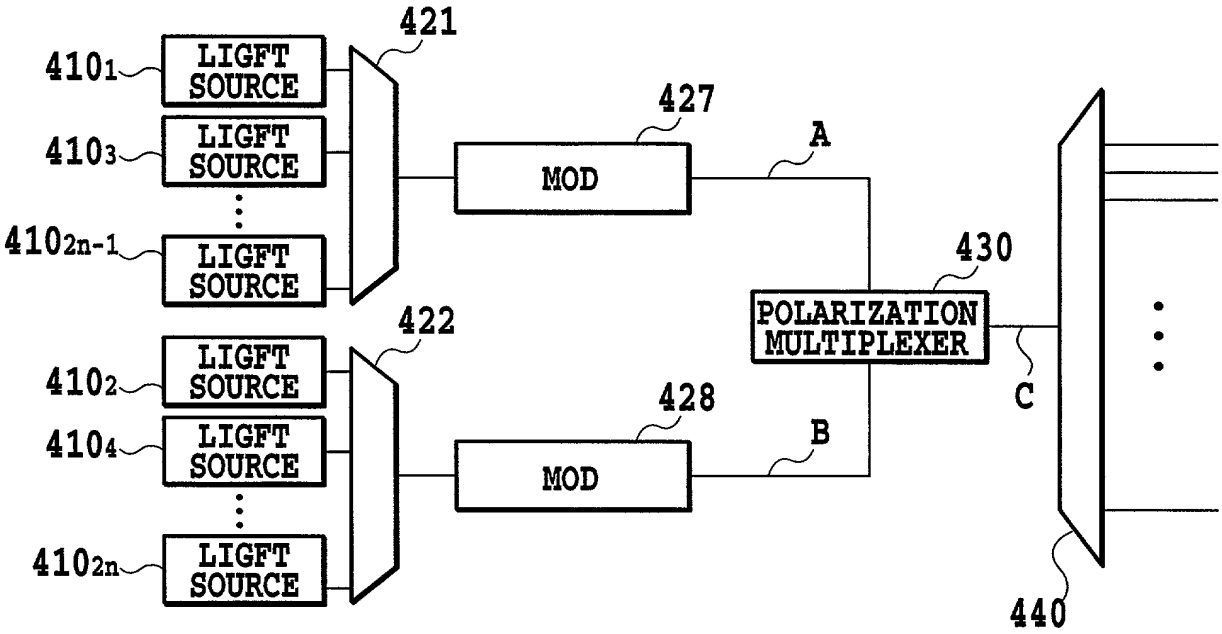
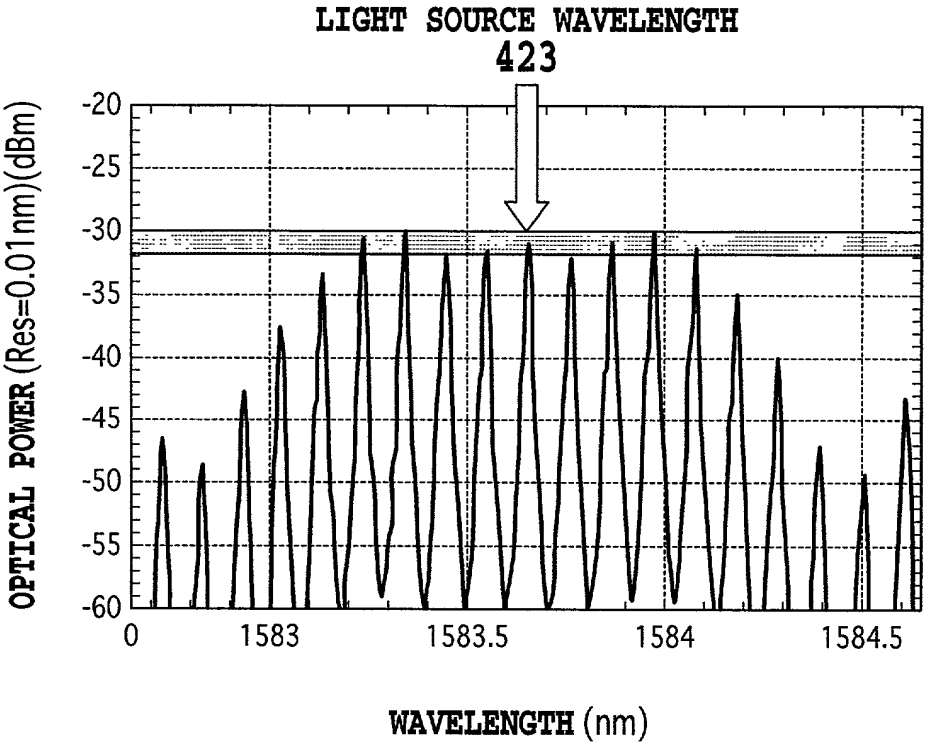
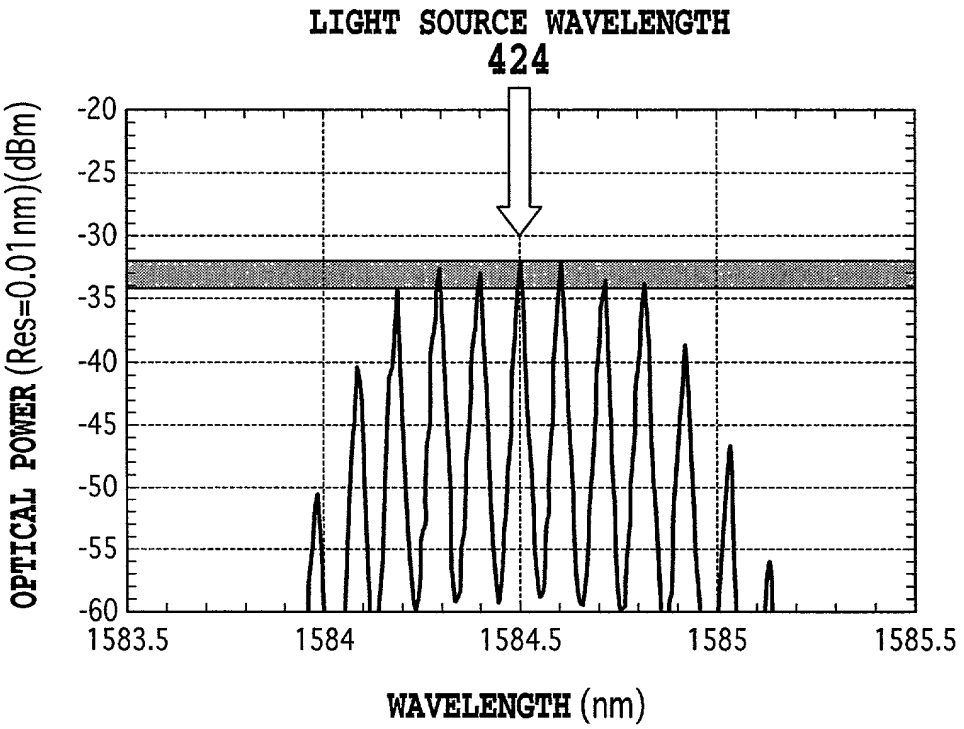

421
410_1
LIGFT SOURCE
410_3
LIGFT SOURCE
410_{2n-1}
LIGFT SOURCE
427
MOD
A
430
POLARIZATION MULTIPLEXER
C
422
410_2
LIGFT SOURCE
410_4
LIGFT SOURCE
410_{2n}
LIGFT SOURCE
428
MOD
B
440

FIG.66



ODD-NUMBER-TH LIGHT SOURCE WAVELENGTH AND SIDE MODES

FIG.67A



EVEN-NUMBER-TH LIGHT SOURCE WAVELENGTH AND SIDE MODES

FIG.67B

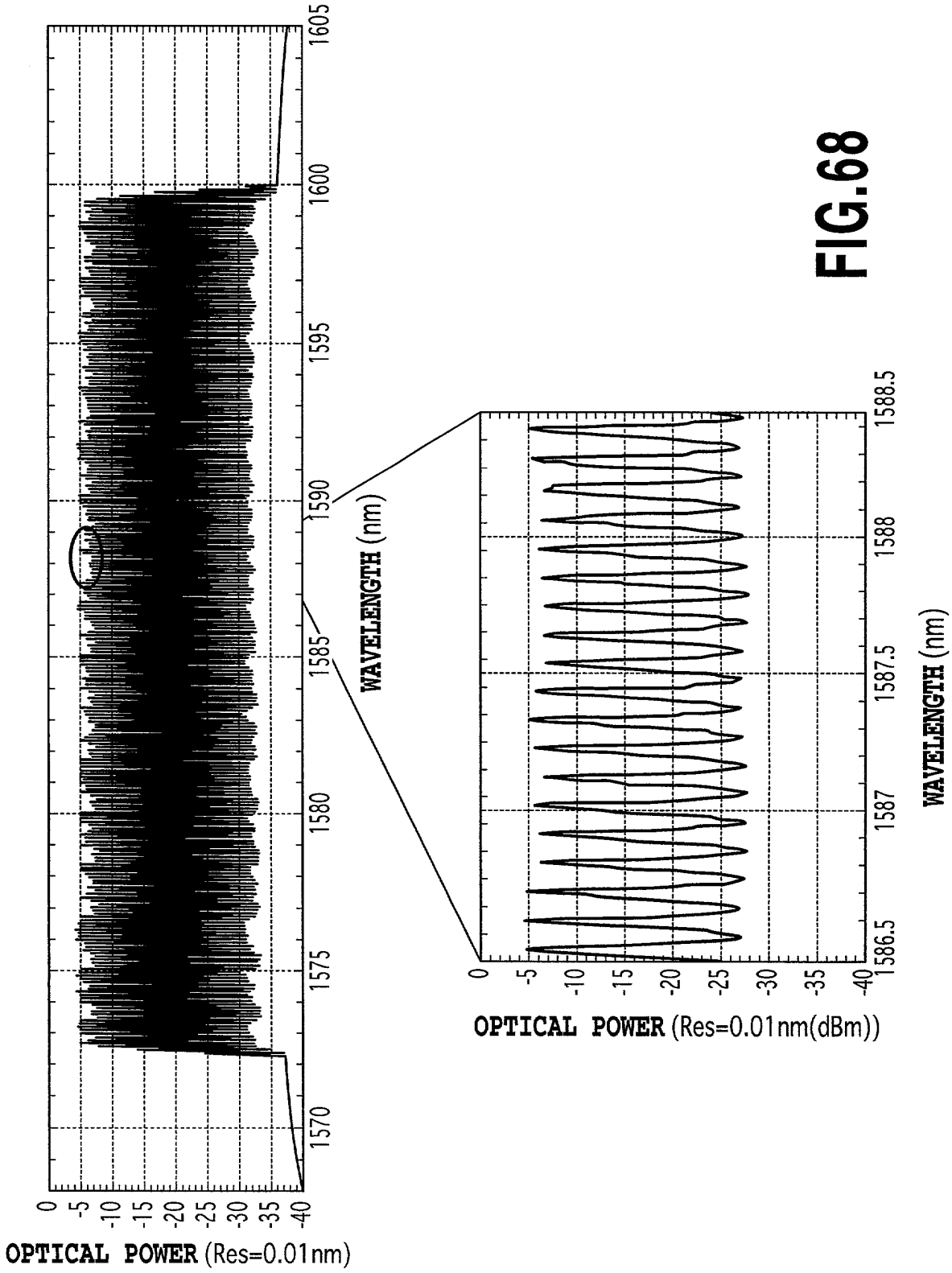

0
-5
-10
-15
-20
-25
-30
-35
-40
1570
1575
1580
1585
1590
1595
1600
1605
OPTICAL POWER (Res=0.01nm)
WAVELENGTH (nm)
0
-5
-10
-15
-20
-25
-30
-35
-40
1586.5
1587
1587.5
1588
1588.5
OPTICAL POWER (Res=0.01nm(dBm))
WAVELENGTH (nm)

FIG.68

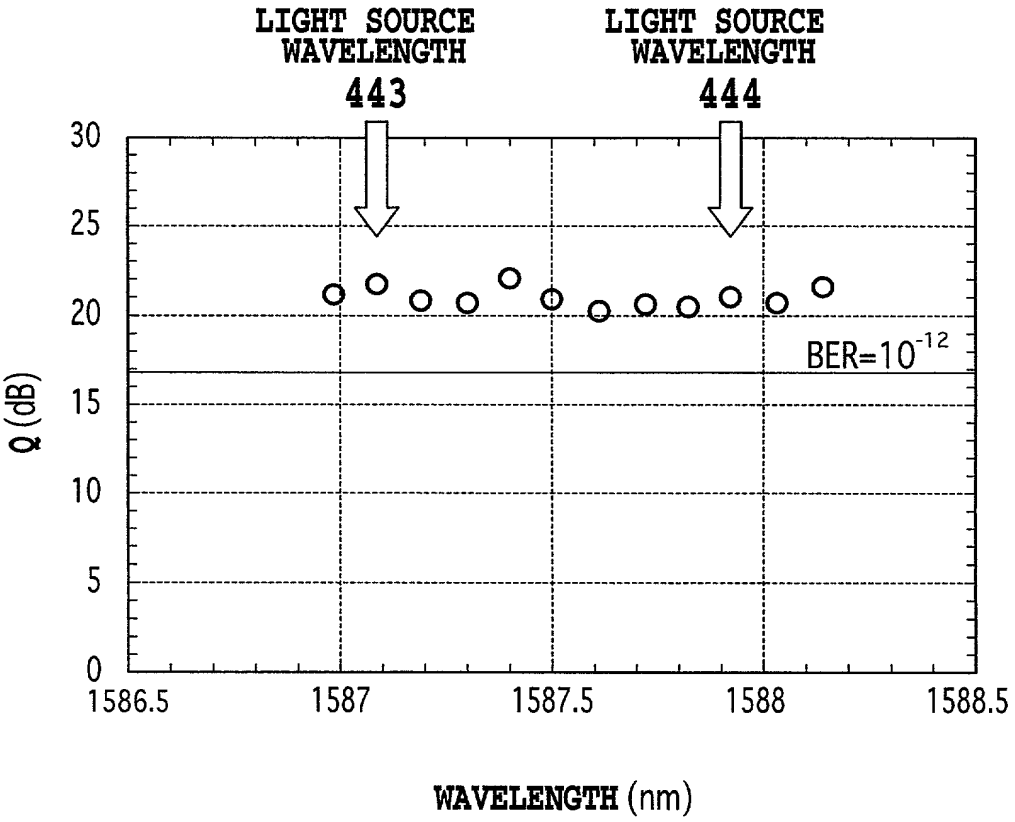

LIGHT SOURCE WAVELENGTH
443
LIGHT SOURCE WAVELENGTH
444
30
25
20
15
10
5
0
Q (dB)
BER=10^-12
1586.5
1587
1587.5
1588
1588.5
WAVELENGTH (nm)

FIG.69

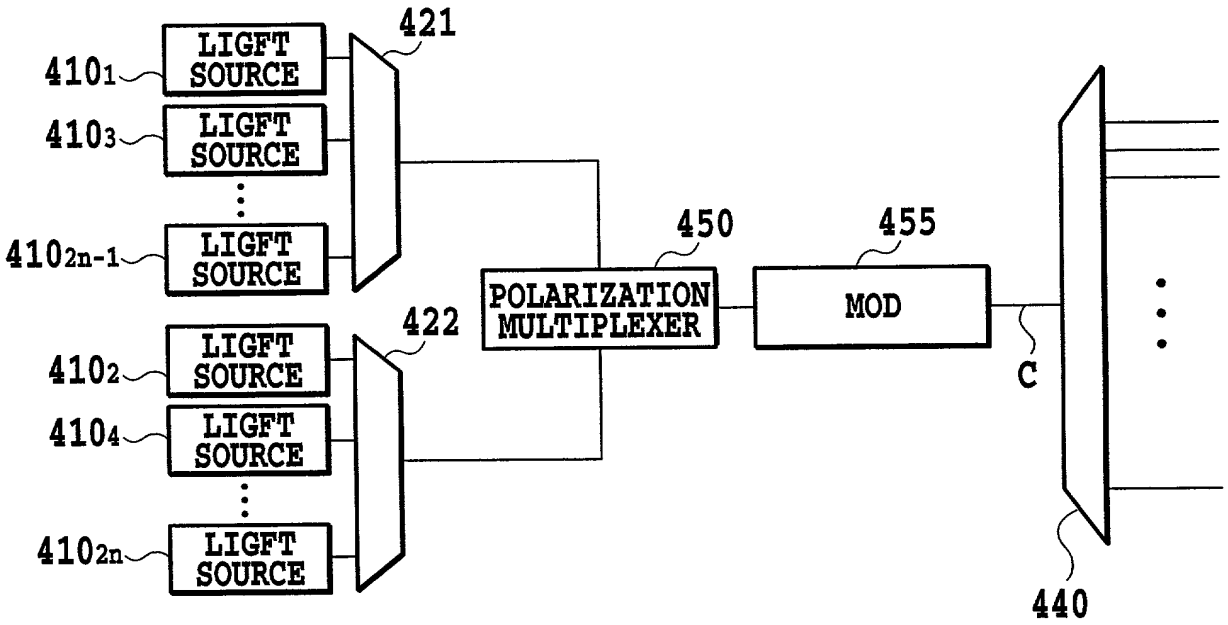

LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
421
422
450
455
POLARIZATION MULTIPLEXER
MOD
C
440

FIG.70

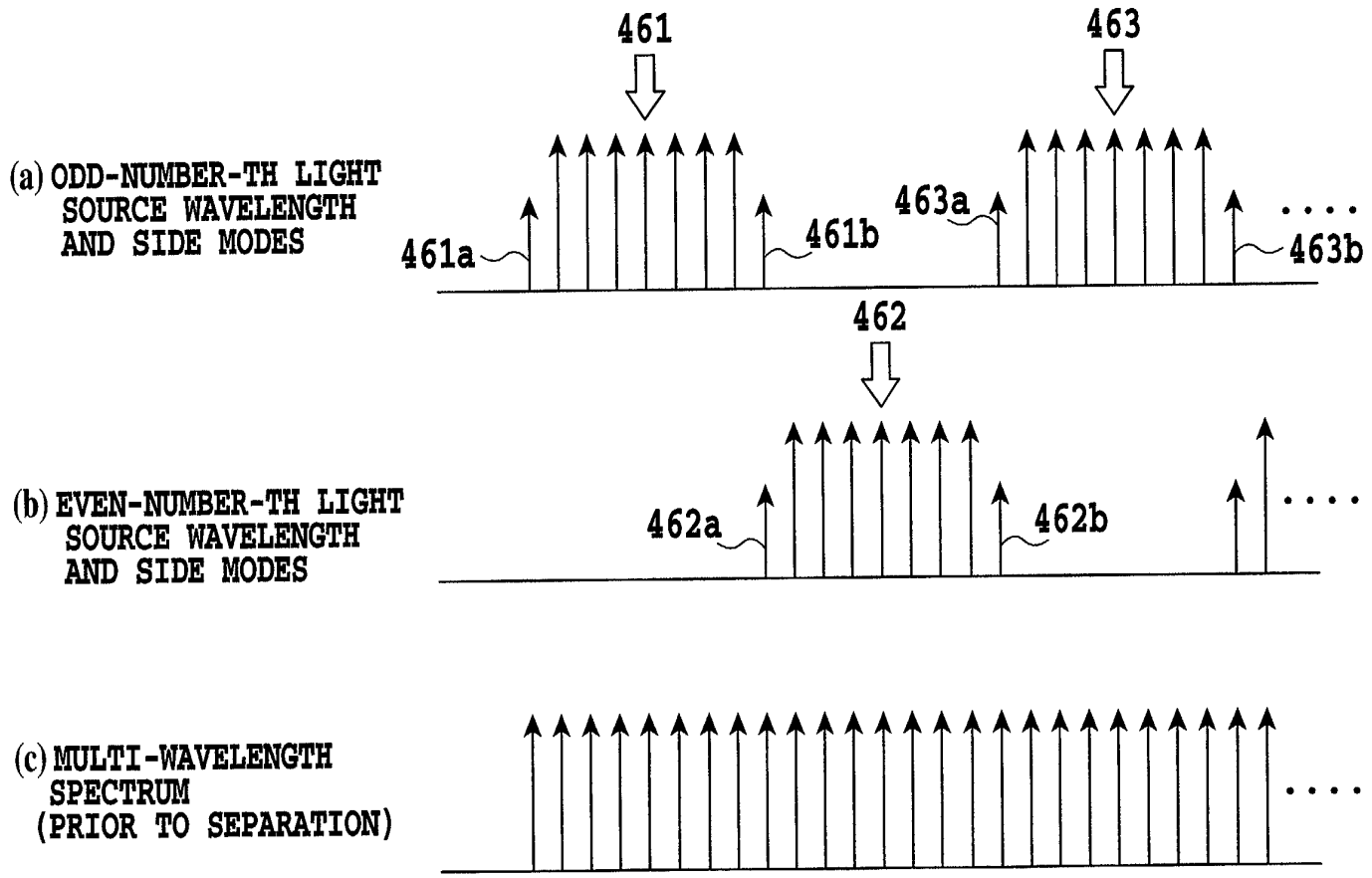


FIG.71